South Cascades Late Successional Reserve Assessment Appendices

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APPENDIX A: AQUATIC-RIPARIAN ECOSYSTEM FUNCTION, ORGANIZATION AND ASSESSMENT

Key Terms

Canopy opening - The amount of open overhead space in a forested area that allows light to penetrate to the ground.

Cover - Structure that provides shelter or resting area for organisms.

Habitat - The area containing food, water, and cover (and the arrangement of these components) needed by an organism to survive and reproduce.

Hydric soils - Soils that are wet long enough to influence the growth of plants.

Hydrophytes, hydrophytic - Plants adapted to wet conditions, as in wetlands.

Large woody material - Logs, root wads, and large branches, usually longer than 10 feet and having a diameter larger than 6 inches.

Mainstem river - The portion of the river containing the main channel or major portion of the water flow.

Microclimate - The climate within a small area or location.

Substrate - Mineral or organic material that forms the bed of a stream.

Windthrow - Uprooting of a tree or group of trees by the wind.

Introduction

Wetlands have been described as the most important habitats on Earth (Mitsch and Gosselink 1986). They have been present for millennia and ancient wetland areas are largely responsible for the fossil fuels we depend on today (Mitsch and Gosselink 1986). Wetlands include the shallow-water aquatic and portions of riparian systems of Pacific Northwest forestlands. These areas are important because they support high species diversity, density, and productivity. They also provide water quality and nutrient processing traits that are critical to the organisms (including humans) that use them.

Aquatic-riparian ecosystems (streams, rivers, lakes, ponds, estuaries, and lagoons) in the United States have been altered significantly by human activity. In 1982, the National Rivers Inventory conducted by the National Park Service found only 2 percent of the 2.35 million stream miles surveyed in the lower 48 states to be "high natural quality" (Behnke 1990). A survey by the U.S. Fish and Wildlife Service (FWS) (Dahl 1990) of wetlands in the lower 48 states found that 53 percent of the wetlands present in the 1780s had been destroyed by the 1980s. This survey estimated the percentage of loss of wetlands in Washington, Oregon, and California as 38, 31, and 91 percent, respectively (Dahl 1990). It did not provide any measure of the quality of the remaining wetlands. Palmisano et al. (1993) estimated that wetlands losses

in Washington were 40 percent of the Columbia River estuary, 70 percent of the Puget Sound estuaries, and about 40 percent of the coastal Washington estuaries.

Common sources of aquatic-riparian ecosystem degradation are changes in water quantity and quality and habitat loss and degradation(USDA et al. 1993). Changes in the physical traits of an ecosystem result in changes to the function (such as nutrient and material processing) and organization (such as species composition and biological community richness) of the ecosystem (USDA et al. 1993). Changes in function and organization may affect the efficiency of the nutrient, material, and energy cycling of the ecosystem (Odum 1985). Changes and stress may also be evident in the species composition and diversity of the ecosystem (Odum 1985, Rapport et al. 1985).

The aquatic and riparian systems in the range of the northern spotted owl (*Strix occidentalis caurina*) are showing signs of ecological stress. Documented loss and simplification of stream habitats (Sedell and Everest 1991, Hicks et al. 1991, Dose and Roper 1994), loss of water quality in lakes (USDI 1993), loss of estuary and wetlands areas (Dahl 1990), and concern about the decline of native species of fish, mollusks, and amphibians (Williams et al. 1989, Nehlsen et al. 1991, Frest and Johannes 1993, Blaustein and Wake 1990) all point to aquatic and riparian systems under stress.

Ecological stress is seen in species communities (Odum 1985, Rapport et al. 1985) as increased rates of disease, widely fluctuating population size (numbers), changes in life history patterns, and changes in population age and size class distributions. These signs of stress are evident in the native fish species in the region (Williams et al. 1989, Nehlsen et al. 1991, Higgins et al. 1992). During the past 100 years human activities have caused the extinction of 27 species and 13 subspecies of North American fish (Miller et al. 1989). At least 106 populations of salmon and steelhead in Washington, Oregon, California, Idaho, and Nevada are extinct or have been extirpated (Nehlsen et al. 1991). The most common cause of extinction was habitat loss, other causes included introduction of nonnative fish species, overfishing, and pollution. Usually more than one of these factors was responsible for the extinction of a species (Miller et al. 1989, Nehlsen et al. 1991).

Characteristics of Aquatic and Riparian Systems and Present Habitat Conditions

Understanding current conditions and future options for aquatic and riparian systems in the Pacific Northwest requires an appreciation of the physical and biological processes and elements that create and maintain habitat. Only recently has the importance of riparian areas been investigated (Oakley et al. 1985, Johnson and Lowe 1985). The riparian system is a zone of transition between the upland terrestrial and aquatic systems where vegetation and microclimate are strongly influenced by the aquatic system (Gregory et al. 1991). The connections between the riparian and aquatic systems are very complex and it has been argued that both the riparian area and associated aquatic area should be considered one ecosystem (Doppelt et al. 1993, Gregory et al. 1991).

USDA et al. (1993) described the critical components of stream and river aquatic and riparian systems and their current conditions in the range of the northern spotted owl. This appendix adds to those descriptions and also presents descriptions of lake, pond, estuary, and lagoon systems.

Aquatic System Components

For this discussion the aquatic systems of the Pacific Northwest are grouped into three classifications: (1) streams and rivers, (2) lakes and ponds, and (3) estuaries and lagoons. The first two classifications are easily associated with the forested lands of the region because they are usually next to or within coniferous forests. The estuaries and lagoons are not usually associated with or mentioned in discussions about the forested lands of the region. They are discussed in this appendix because they are directly connected to the streams and rivers, receiving freshwater inflow and materials from upstream watersheds and providing important habitats for the region's migratory and resident wildlife and fish species and other organisms (Vannote et al. 1980). The following discussion focuses on the stream and river systems of the region, but also discusses lakes, ponds, estuaries, and lagoons to provide a picture of the connection and continuation of the aquatic realm from headwater streams to the ocean (Vannote et al. 1980).

Streams and Rivers

Key physical components of a fully functioning stream system include complex habitats consisting of flood plains, banks, pools, riffles and runs (channel structure), a water column, and subsurface flowing waters. These are created and maintained by rocks, sediment, large woody material, and favorable conditions of water quantity and quality. Upslope and riparian areas influence stream systems by supplying sediment, large woody material, and water. Disturbance processes such as landslides and floods are important delivery mechanisms. Many species may require periodic disturbances to provide habitat components such as large woody material and coarse gravels. To maintain community viability throughout a large drainage basin, it is necessary to maintain features of the natural disturbance regime (i.e., frequency, duration, and magnitude) in different portions of a basin. This spatial and temporal separation is important to allow the physical and biological systems to recover (Burns 1972). Aquatic systems consist of a diversity of species, populations, and communities that may be uniquely adapted to these specific structures and processes. Prolonged disturbances (such as continuing logging and road building activities in a watershed over many years) damage stream habitat and fish populations (Burns 1972).

Aquatic organisms in the Pacific Northwest receive energy from two sources: organic material and sunlight (Murphy and Meehan 1991, Swanson et al. 1981). The contribution of each source may vary depending on conditions in the aquatic system (Swanson et al. 1981). The input of organic material provides an energy base for stream organisms. Twigs, needles, and leaf litter are a quickly processed short-term energy source for stream organisms, while large woody material is a slowly processed, long-term part of the energy base. Organic material provides the major source of energy for headwater streams (Oakley et al. 1985, Everest et al. 1985).

The relationship of seepages and springs to aquatic systems can be difficult to assess. Though they have some flowing water and may have saturated areas, they are often not clearly aquatic, riparian, or wetland. Seepages and springs are characterized by low water flow rates and clear, shallow water percolating through moss-covered gravel and cobbles. They include areas where water flows from the ground in a spot not directly associated with streams, points where water flows into the edges of larger streams and feeds ponds and lakes, and small perennial headwater streams that are associated with groundwater discharge. Mosses and ferns often

dominate the areas in or near seepages and springs. Regardless of what we call these, they can be important wet habitats.

Sunlight reaching the bottom of the stream warms the water and provides a base for photosynthesis which stimulates the growth of algae (Swanson et al. 1981). Photosynthesis, and the algae growth it produces, provide a short-term energy base for stream organisms and organic matter input to the stream. This input may be more important than the contribution made by shoreline vegetation (Swanson et al. 1981). In a fully-functional tributary stream sunlight is minimized by shading from the forest canopy and watershed topography.

Large woody material provides an energy buffer for the stream when short-term organic material and sunlight are at a minimum. It may be several years before large woody material contributes to the energy base, but in the interim it provides cover, stream structure, substrates for the biological activity of aquatic invertebrate communities, and complexity to the stream system (Meehan et al. 1977).

Streams and rivers in the Pacific Northwest are classified by "order" (Strahler 1957), with small undivided headwater streams being first-order and large mainstem rivers being higher-order waterways (usually fifth- or sixth-order streams) (Everest et al. 1985).

First- and second-order streams make up the majority of the stream mileage in watersheds of western Washington and Oregon. In western Oregon, 79 percent of the stream mileage are composed of first and second order streams (Boehne and House 1983). These waterways gain most of their initial runoff from precipitation and are often dry in the summer. The vegetation canopy associated with these streams is usually complete and provides continuous shade (Chamberlain et al. 1991). Large woody material may cover 50 percent of the channel area which provides bank stability and promotes retention of organic material and sediment. In addition, they provide a large amount of woody material to downstream areas (Everest et al. 1985). These headwater streams determine the type and quality of fish habitat in downstream areas (Chamberlain et al. 1991, Maser et al. 1988). The energy and nutrient inputs of these small streams are provided by organic material from the adjacent terrestrial area in the form of leaf litter, cones, branches, and twigs (Bilby 1988, Triska et al. 1982, Vannote et al. 1980). Any removal or alteration of streambank vegetation or canopy will influence the stream's energy supply (Chamberlain et al. 1991). The influence of this disturbance will be felt not only in the immediate area but also in downstream reaches and larger streams downstream (Chamberlain et al. 1991, Vannote et al. 1980). These streams usually have elevation gradients of more than 10 percent. These streams and their associated riparian areas are influenced by the surrounding terrestrial area. The riparian areas of first and second order streams are usually smaller than those of larger order streams as a result of the usually steep slopes of the upland forested area (Bilby 1988). Salmonids (*Oncorhynchus spp.*) in the Pacific Northwest migrate to some of these streams to spawn and rear before migrating to larger streams during the summer (Chamberlain et al. 1991). Streams in these orders that are inaccessible to migrating fish are still important to the quality of downstream habitats (Chamberlain et al. 1991).

Third- and fourth-order streams usually contain water year-round. They have a gentler gradient than their smaller tributaries, usually less than 5 percent. The vegetation canopy over these streams ranges from completely closed to open. Large woody material covers about 25 percent of the channel. The primary energy input is from upstream first and second order streams and organic material (such as leaf litter and twigs) rather than sunlight hitting the streams because the canopy closure over most of these streams (Bilby 1988). These streams

and second-order streams are primary spawning and rearing habitats for fish species such as coho salmon (*O. kisutch*), steelhead trout (*O. mykiss*), coastal cutthroat trout (*O. clarki clarki*) (Everest et al. 1985), and Pacific lamprey (*Lampetra tridentata*)(Scott and Crossman 1973). Fifth- and sixth-order streams and rivers in the Pacific Northwest have complex channels with features such as side channels, overflow channels, meanders, and isolated pools. Canopy cover does not provide much shade, but at these stream orders, water temperatures are moderated by other factors such as water depth and volume. The primary energy input is sunlight. Because the volume of water and the usually gentler topography, these large streams and rivers have larger floodplains, riparian, and wetlands areas associated with them than first through fourth order streams. The gradient is usually less than 1 percent. Water quality in these waterways is often determined by water quality of upstream tributaries and runoff from adjacent terrestrial areas (Everest et al. 1985).

Components discussed next are characteristic of third- to fifth-order streams. These streams are generally 10 to 60 feet wide and are representative of most stream systems within the range of the northern spotted owl. Streams of this size support mixed species assemblages of juvenile anadromous salmonids, resident fish, mollusks, amphibians, and insects. Not all of the components are expected to occur in a specific reach of stream, but they generally occur throughout a productive watershed.

Large woody material. Large quantities of down logs, root wads, and large limbs are a functionally important component of many stream and river systems (Swanson et al. 1976, Sedell and Luchessa 1982, Sedell and Froggat 1984, Sedell et al. 1985, Harmon et al. 1986, Bisson et al. 1987, Maser et al. 1988, Naiman et al. 1992). Large woody material enters streams inhabited by fish either directly from the adjacent riparian area from tributaries that may not be inhabited by fish or from hillsides (Naiman et al. 1992). Large woody material influences channel morphology by affecting longitudinal profile, pool formation, channel pattern and position, and channel geometry (Bisson et al. 1987, Sedell et al. 1985) and maintaining channel stability (Heede 1985). It also affects the formation and distribution of stream habitats, provides cover and habitat complexity, and acts as a substrate for biological activity (Swanson et al. 1982, Bisson et al. 1987). Pools and low-velocity stream margins (important aspects of the stream's habitat complexity) are important habitat components for adult and juvenile fish (Meehan 1991, see Appendix B). Logs in the stream channel act as hydraulic control points and prevent excessive bedload movement (Heede 1985). Downstream transport rates of suspended sediment and organic matter are controlled in part by storage of this material behind large woody material (Betscha 1979, Sedell et al. 1985).

Trees which fall across streams or small canyons serve as bridges for such species as bobcats (*Lynx rufus*), marten (*Martes americana*), flying squirrels (*Glaucomys sabrinus*), deer mice (*Peromyscus* spp.) and jumping mice (*Zapus* spp.). In addition, large woody material that is partly submerged in water are important as preening sites for waterfowl, sunning areas for turtles, and feeding and nesting sites for mink (*Martes vison*) and river otters (*Lutra canadensis*). Logs whose hollow ends extend over streams are occasionally used as nesting sites by dippers (*Cinclus aquaticus*) (Maser et al. 1979).

Large woody material is an important component of fish habitat (Sedell et al. 1985, Bisson et al. 1987, Reeves et al. 1991). The relationship between the amount of low-velocity water flow habitat and stream discharge was studied by Kaufman (1987), who compared undisturbed stream channels containing large woody material and stream channels with boulder berms built to enhance habitat. Findings from this work showed that as discharge increased the area of

low-velocity water flow increased in the stream containing the large woody material, but remained the same in the channel with the boulder berms. Deep pools containing large woody material were found to contain the majority of overwintering salmonids in a southeastern Alaskan stream (Heifetz et al. 1986). In another study in southeastern Alaska, a decline in juvenile salmonid production was seen in two streams that were cleaned of woody material. Large, stable, woody material is important winter habitat for coho salmon, steelhead trout, and coastal cutthroat trout (Maser et al. 1988) because it enhances the use of other habitats within pools. Yearling coho salmon and Dolly Varden (*Salvelinus malma*) were the fish species most affected by the loss of the overwintering habitat (Dolloff 1986). In a similar study in southeastern Alaska, Elliot (1986) found a loss of larger Dolly Varden and a decrease in the average size of fish in a small stream after removal of logging material. Woody material in large rivers along the stream margins are used by juvenile salmonids as rearing areas (Maser et al. 1988).

The removal of natural, stable woody material, may seriously damage the stream channel and the streamside riparian habitat. Such woody material provides excellent habitat for aquatic and amphibious wildlife and for many small terrestrial animals. Woody material that is buried in the streambed frequently create small waterfalls and plunge pools which aerate the water and increase habitat diversity.

Large woody material in streams has been reduced by a variety of past and present timber harvest practices and associated activities (Sedell et al. 1985). It was removed through splash-damming, opening navigational channels, removing slash from streams and streamside areas, and removing log jams to improve fish passage in some streams (Sedell et al. 1985). These actions greatly impacted salmonid habitats (Reeves et al. 1991). Many riparian management areas on federal and nonfederal lands are inadequate as long-term sources of large woody material. Widths of intact riparian areas have been reduced by timber harvest activities. In some areas where riparian buffers have been established, partial harvest and salvage logging in the buffers have reduced the contribution of large woody material to streams (Bisson et al. 1987). Also, the absence of protection for riparian areas of nonfish-bearing streams has reduced the amount of large woody material these streams could deliver to fish-bearing streams (Naiman et al. 1992). Debris flows and dam-break floods resulting from natural processes or timber harvest activities may remove large woody material from channels and riparian vegetation from streambanks in one portion of a drainage system and deposit them downstream (Benda and Zhang 1990, Swanston 1991).

Water quality. High water quality is essential for survival, growth, reproduction, and movement of organisms in aquatic and riparian communities. Desired conditions include an abundance of cool, well-oxygenated water that is present year-round, and free of excessive amounts of suspended sediments (Sullivan et al. 1987) and other pollutants that could limit primary production and benthic invertebrate abundance (Cordone and Kelley 1961, Lloyd et al. 1987).

Elements of water quality that are important for aquatic organisms include water temperatures within a range that corresponds with migration and emergence needs of fish and other aquatic organisms (Sweeney and Vannote 1978, Quinn and Tallman 1987). Water has a high heat capacity, and a stream's volume, depth, and turbulence affect the actual water temperature. Sunlight is the major source of energy available to warm the water of a stream in the summer (Chamberlain et al. 1991). Increased water temperature can often be traced to removal of shade-producing riparian vegetation along fish-bearing streams and along smaller tributary streams that supply cold water to fish-bearing streams (Beschta et al. 1987, Bisson et al. 1987,

Theurer et al. 1985). Also, channel widening and resultant reduction in water depth will cause increases in summer water temperature (Dose and Roper 1994). Small streams may have a greater potential for increases in water temperature from streamside timber harvest than larger streams because more of their surface area would be exposed to sunlight (Chamberlain et al. 1991). Timber harvest in riparian areas is the main cause of removal of streambank vegetation (Chamberlain et al. 1991). If the streamside riparian area is altered, small streams may also experience lower winter temperatures (Betscha et al. 1987, Koski et al. 1984, Platts 1984), which can affect the development, growth, and survival of aquatic organisms by lengthening incubation periods and increasing the risk of freezing conditions.

Elevated water temperatures can affect the survival and production of anadromous and resident salmonids and other aquatic organisms, even when temperatures are lower than levels considered to be lethal (Armour 1991). McPhail and Murray (1979) found that bull trout egg survival to hatching increases with decreasing water temperature; water temperatures of 36° to 43°F provide 60 to 95 percent survival while water temperatures of 46° to 50°F provide 0 to 20 percent survival. There is also some evidence that water temperatures may dictate distribution of bull trout within a basin (Pratt 1992). Berman and Quinn (1991) found that fecundity and viability of eggs of adult spring chinook salmon (*Oncorhynchus tshawytscha*) were affected by elevated water temperatures. Although the upper lethal water temperature limit for juvenile chinook salmon (*O. tshawytscha*) is about 77°F, growth can be suppressed at about 59°F, with growth stopping at 66°F (Armour et al. 1991). In western Oregon, Reeves et al. (1987) found that competition between redside shiners (*Richardsonius balteatus*) and juvenile steelhead trout was influenced by water temperature: steelhead trout dominated at lower temperatures (less than 68°F) and shiners at higher temperatures (more than 68°F). In Carnation Creek, British Columbia, water temperatures during summer and winter changed because of timber harvest activities and resulted in accelerated growth and earlier migration of juvenile coho salmon (Holtby 1988). Holtby (1988) speculated that survival of coho salmon to adults would decrease because of the earlier time of ocean entry.

In the Pacific Northwest, several species of amphibians are adapted to cold, clear water conditions. The tailed frog (*Ascaphus truei*) has the lowest upper limiting temperature for embryonic development (65°F) of any cold-adapted frog in North America (Brown 1975). Claussen (1973) found that adult tailed frogs die within 8 hours when exposed to water at 78°F. The typical stream temperatures where the young of this species were found ranged from 32° to 60°F (Brattstrom 1963), and young-of-the-year appeared to seek temperatures near 32°F.

Accelerated rates of erosion and sedimentation are a consequence of most forest management activities (Waters 1995). The sediment contribution to streams from roads is often much greater than that from all other land management activities combined, including log skidding and yarding (Gibbons and Salo 1973, Waters 1995). Road-related landsliding, surface erosion, and stream channel diversions frequently deliver large quantities of sediment to steams, both chronically and catastrophically during large storms (Reid and Dunne 1984). Roads may have unavoidable effects on streams, no matter how well they are located, designed, or maintained. Many older roads pose high risks of erosion and sedimentation of stream habitats because they are poorly located and have inadequate drainage control and maintenance (Furniss et al. 1991).

Increased levels of sedimentation often have adverse effects on aquatic vertebrate habitats and riparian systems (Waters 1995, Frissell 1992). Increased sediment loads tend to increase the width to depth ratio of a stream, resulting in a shallower, warmer stream (Lyons and Beschta

1983). Fine sediment deposited in spawning gravels can reduce survival of salmonid eggs and developing alevins (Everest et al. 1987, Hicks et al. 1991). Filling of interstitial spaces and sediment accumulation in backwater pools and stream edges can negatively affect all aquatic life stages of amphibians and invertebrates (Corn and Bury 1989, Hawkins et al. 1983). Primary production, benthic invertebrate abundance, and food availability for fish and amphibians may be reduced as sediment levels increase (Cordone and Kelley 1961, Lloyd et al. 1987). Social (Berg and Northcote 1985) and feeding behavior (Noggle 1978, Sigler et al. 1984) can be disrupted by increased levels of suspended sediment. Pools, an important habitat type, can be destroyed or severely reduced in size due to increased levels of sediment (Kelsey et al. 1981, Megahan 1982).

Corn and Bury (1989) documented declines in amphibian species richness and in the density and biomass of southern torrent salamanders (*Rhyacotriton variegatus*), tailed frog larvae, and Pacific giant salamanders (*Dicamptodon tenebrosus*) in logged versus unlogged streams in southern Oregon. They attributed these declines to loss of critical microhabitat as a result of addition of fine sediments. Populations of stream amphibians can be particularly sensitive to increased siltation because they use interstitial spaces among the loose, coarse substrates as forage and cover areas. These substrates make up the matrix of natural streambeds in the Pacific Northwest (Bury and Corn 1988, Corn and Bury 1989, Welsh and Ollivier 1992). Sedimentation fills these spaces, reducing the available cover and foraging area for amphibians and their prey.

Water quantity. Aquatic organisms require that adequate streamflows be maintained at critical times to satisfy requirements of various life stages. For example, fish are adapted to natural variations in flow regimes but may be adversely affected by disturbances that alter natural flow cycles (Statzner et al. 1988). Timing, magnitude, duration, and spatial distribution of peak and low flows must be sufficient to create and sustain stream and riparian systems habitats and to retain patterns of sediment, nutrient, and large woody material routing. The timing, variability, and duration of flood plain inundation and water table elevation in meadows, flood plains, and wetlands affect maintenance of side channels, pools, and main channel areas and the connectivity between these areas.

Timber harvest and associated activities can alter the amount and timing of streamflow by changing onsite hydrologic processes (Keppeler and Ziemer 1990, Wright et al. 1990, Jones and Grant 1996). These activities, which include harvest, thinning, yarding, road building, and slash disposal, can produce either short-term or long-term changes depending on which hydrologic processes they alter and the intensity of the alteration (Harr 1983). Changes in the hydrologic system caused by road building are most pronounced where road densities are the greatest (Harr et al. 1979, Wright et al. 1990, Ziemer 1981, Jones and Grant 1996). Similarly, the effects of clear-cut logging on hydrologic processes are greater than those resulting from thinning (Harr 1983, Harr et al. 1979, Jones and Grant 1996).

Changes in hydrologic processes can be grouped into two classes according to causal mechanisms: (1) the changes resulting from removing forest vegetation through harvest and (2) the changes controlling infiltration and the flow of surface and subsurface water. Changes in the first class, which can be significant close to the harvest areas immediately following harvest, gradually diminish over time as vegetation regrows (Harr 1983, Harr et al. 1979, Harris 1977, Hicks et al. 1991). Processes that depend on the amount and size of forest vegetation include rain or snow interception, fog drip (Azevedo and Morgan 1974, Byers 1953, Harr 1982, Ingwerson 1985), transpiration (Harr 1983; Harr et al. 1979, 1982), and snow accumulation and

melt (Berris and Harr 1987, Coffin and Harr 1992, Harr 1981, Troendle 1983, Swanson and Golding 1982). These processes, most of which are at least partially energy-dependent, all increase the amount or timing of water arriving at the soil surface and the resultant amount of water flowing from a logged watershed. Changes in these processes that are caused by timber harvest generally last 30 to 40 years and are related to vegetation characteristics such as tree height, leaf area, canopy density, and canopy closure (Coffin and Harr 1992, Harr and Coffin 1992, Troendle 1983, Hicks et al. 1991).

The second class of changes in hydrologic processes is dominated by the effects of forest roads. The relatively impermeable surfaces of roads cause runoff that bypasses longer, slower subsurface flow routes (Harr et al. 1975, 1979; Ziemer 1981). Where roads are insloped to a ditch, the ditch extends the drainage network, collects surface water from the road surface and subsurface water intercepted by roadcuts, and transports this water quickly to streams (Megahan et al. 1992). Changes in hydrologic processes resulting from forest roads are as permanent as the roads. Until a road is removed and natural drainage patterns are restored, the road is likely to continue to affect the routing of water through watersheds.

In watersheds of 20 to 200 square miles, increased peak flows have been detected after road building and clear-cutting (Christner and Harr 1982). Higher flows result from a combination of wetter, more efficient water-transporting soils following reduced evapotranspiration (Harr et al. 1982, Harris 1977); increased snow accumulation and subsequent melt during rainfall (Berris and Harr 1987, Harr 1986, Harr and Coffin 1992); surface runoff from roads (Harr et al. 1975, 1979); extension of drainage networks by roadside ditches; and possibly reduced roughness of stream channels following debris removal and salvage logging in riparian areas.

The alteration in streamflow regime resulting from timber harvest and associated activities can have positive and negative effects on stream systems (Hicks et al. 1991). For example, decreased evapotranspiration following logging and before vegetation regrowth can increase summer streamflows that may bring about short-term increases in juvenile salmonid survival. Conversely, increased peak flows may increase bed-load movement and reduce survival of salmonid eggs and alevins. Increased spring-time streamflows that result in flood events can also destroy nest sites of bird species that use the riparian areas, such as the harlequin duck (*Histrionicus histrionicus*) (Cassirer 1994 personal communication). Effects of streamflow changes on aquatic organisms have not been documented independently from other logging effects. The extent to which the positive effects of short-term increase in summer streamflows are offset by the detrimental effects of increased peak streamflows and resultant scour is unknown (Hicks et al. 1991).

Inchannel habitat. A primary factor influencing the diversity of stream communities is habitat complexity. Attributes of habitat complexity include the variety and range of hydraulic conditions (i.e., depths and water velocities) (Kaufmann 1987), number of pieces and size of wood (Bisson et al. 1987), types and frequency of habitat units, variety of streambed substrate (Sullivan et al. 1987), and stream edges (Bisson et al. 1982). More diverse habitats support more diverse assemblages and communities (Gorman and Karr 1978, Schlosser 1982, Angermeier and Karr 1984). The complexity and diversity of stream habitats can also mediate biotic interactions such as competition (Kalleberg 1958, Hartman 1965) and predation (Crowder and Cooper 1982, Schlosser 1988).

Roads modify natural hillside drainage networks and accelerate erosion processes. These changes can alter physical processes in streams, leading to changes in streamflow regimes,

sediment transport and storage, channel bank and streambed configurations, substrate composition, and stability of slopes adjacent to streams. These changes can have significant biological consequences that affect virtually all components of stream systems, including pools, side channels, low-velocity stream margins, and streambanks (Furniss et al. 1991).

Large pools, a primary characteristic of high-quality stream systems, have been destroyed in basins that have had varying levels of land management. The loss of pools has been associated with declines in fish abundance in Pacific Northwest streams (Bisson et al. 1987). Hicks (1990) found that the number of pools associated with large woody material decreased in proportion to the percentage of the basin that had been logged. This decrease occurred in basalt and sandstone parent rock basins. Bilby and Ward (1991) found that streams in old-growth forests hold more pools for a given channel width than streams in clearcuts or in second-growth forests. These large pools are important for fish such as spring chinook salmon and summer steelhead trout that use these habitats while waiting to spawn, and to juvenile fish rearing in the streams (see Appendix B). The number of large, deep pools (i.e., more than 6 feet deep and more than 50 square yards of surface area) in many tributaries of the Columbia River has declined in the past 50 years (Sedell and Everest 1991, McIntosh 1992). Over all, there has been a 58 percent reduction in the number of large, deep pools in resurveyed streams in national forests in the range of the northern spotted owl in western and eastern Washington. A similar trend was found in streams on private lands in coastal Oregon, where the number of large, deep pools decreased by 80 percent. Ralph et al. (unpublished manuscript) reported a decline in the number of pools in streams in basins with moderate (less than 50 percent of the basin harvested in the last 40 years) to intensive (more than 50 percent of the basin harvested in the last 40 years and a road density of more than 5.3 miles per square mile) levels of timber harvest in western Washington. Bisson and Sedell (1984) reported similar results for other streams in western Washington. Primary reasons for the decline in the number of pools are filling by sediments (Hicks et al. 1991, Megahan 1982), loss of pool-forming structures such as boulders and large woody material (Hicks et al. 1991, Bryant 1980, Sullivan et al. 1987), and loss of sinuosity by channelization (Furniss et al. 1991, Benner 1992).

Loss of habitat complexity (habitat simplification) may result from timber harvest activities (Bisson and Sedell 1984, Hicks et al. 1991, Bisson et al. 1992). A decrease in the number and quality of pools and stream margins is a consequence of timber harvest activities and other land-use impacts (Chamberlain et al. 1991, Sullivan et al. 1987). Changes in stream channel morphology (widening) has been shown to be positively correlated to the amount of both timber harest and road density (Dose and Roper 1994). Large woody material is a major habitat-forming element in streams (Hicks et al. 1991, Bisson et al. 1992). Reduction of large woody material in the channel, either from past or present activities, generally reduces pool quantity and quality and low-velocity stream margins (House and Boehne 1987, Bisson et al. 1987). Constricting naturally unconfined channels with bridge approaches or streamside roads reduces stream meandering and decreases the number and size of pools formed by stream meanders that undercut banks (Furniss et al. 1991). Increased mass failures from roads and timber harvest on unstable slopes can reduce the number of pools due to sediment influxes (Swanson et al. 1982).

Stream and river channelization reduces inchannel habitat diversity. Many of the streams and rivers in the Pacific Northwest and Northern California have been altered to reduce meanders, reclaim wetland areas, reduce flooding, and provide better river navigation channels (Maser et al. 1988). The Puget Sound and Chehalis River area of Washington and the Willamette Valley of Oregon are examples of stream and river systems that have been altered through

channelization. These systems were first altered for river navigation and log transportation, and latter for urbanization and flood control. Channels that are riprapped or held in place with levies, or constrained by some other method may never develop meander patterns. This lack of meander pattern and lack of natural variation in channel gradient will greatly reduce the habitat diversity necessary for the native aquatic species. In the Willamette River, the range of the Oregon Chub (*Oregonicthys crameri*) has been reduced to a small fraction of its historical range due to channelization (Appendix B).
In Pacific Northwest streams, habitat simplification resulting from timber harvest and associated activities leads to decreased diversity of the anadromous salmonid complex (Bisson and Sedell 1984, Li et al. 1987, Hicks et al. 1991). One species may increase in abundance and dominance while others decrease. Holtby (1988), Holtby and Scrivener (1989), and Scrivener and Brownlee (1989) in British Columbia and Rutherford et al. (1987) in Oklahoma reported similar responses by fish communities in streams affected by timber harvest activities. Similar patterns have also been observed in streams altered by other human activities such as agriculture (Schlosser 1982, Berkman and Rabeni 1987) and urbanization (Leidy 1984, Scott et al. 1986).

Connectivity. Spatial and temporal connectivity within and between watersheds is necessary for maintaining stream and riparian systems functions (Naiman et al. 1992). Lateral, vertical, and drainage network linkages are critical to stream system function. Important connections within basins include linkages among headwater tributaries and downstream channels as paths for water, sediment, and disturbances, and linkages among flood plains, surface water, and ground water systems as exchange areas for water, sediment, and nutrients. Supply of large woody debris from headwater areas and larger streams to lakes , ponds, estuaries, and ocean areas are also important to provide key habitat and energy components for these areas (Maser et al. 1988). Unobstructed physical and chemical paths to areas critical for fulfilling life history requirements of aquatic- and riparian-dependent species must also be maintained. Connections between basins must allow for movement between areas of shelter. Connectivity within and among watersheds allows for recolonization of aquatic and terrestrial organisms following local extinctions resulting from disturbances (Rieman and McIntyre 1994).

Lakes and Ponds

Lakes and ponds can be generally classified as nutrient-rich, high-organic production, or nutrient-poor, low-organic production. The characteristics of lakes and ponds (surface area, depth, water exchange, and terrestrial, riparian, and stream input) are major factors in determining the productivity levels of these bodies of water (Ruttner 1974).

Man-made lakes and reservoirs typically have a period of intense productivity in the short term after being created. In the long term, systems come into balance, production decreases and stabilizes at lower levels than were present in the short term.

Characteristics of lakes and ponds are largely determined by the topography, climate, and geology of the surrounding area. Lakes and ponds are sensitive to nutrient and material cycling and input from surrounding streams and riparian and terrestrial systems because water is in lakes and ponds longer than it is in streams and rivers where the streambeds are always in contact with new water (Ruttner 1974). The energy sources are sunlight and organic material, similar to the stream and river systems.

Since water exchange is slower in lakes and ponds, changes in water quality occur relatively fast, and degraded water quality conditions can last longer than events occurring in streams and rivers. Lake and pond communities respond relatively rapidly to degraded water quality conditions. For example, increased nutrient inputs, from watershed soil erosion, can cause increased rates of primary productivity. These changes in primary productivity, when taken into account with other changes in water quality, can impact all components of lake and pond systems.

Stormwater runoff from urban and industrial sources can result in chemical pollution of surface waters. Likewise, runoff from rural land uses, including timber harvest and associated activities as well as agricultural land uses, can result in inputs of chemical pollutants and sedimentation of surface water and ground water. These sources of pollution affect the physical and biological processes, with resultant impacts on the biological communities (USDI 1993). For example, these land uses are linked to major declines in fish communities in Puget Sound and other estuary areas in Washington (Palmisano et al. 1993), in the Upper Klamath Lake area in Oregon (USDI 1993), and in the Clear Lake drainage of Lake County (Moyle 1976, Moyle et al. 1989) and the Sacramento-San Joaquin River delta (Moyle et al. 1989) in California.

Estuaries and Lagoons

An estuary can be defined as a coastal indentation that receives freshwater inflow, has restricted connection to the ocean, and remains open to the ocean at least intermittently (Day et al. 1989). This definition includes river mouths, lagoons, and river deltas. Estuaries are located at the transition between freshwater and ocean environments. Like riparian areas that form a edge between upland and aquatic areas in the forest and share species from upland and aquatic areas, estuaries are also productive and rich in species numbers (Day et al. 1989, Mitsch and Gosselink 1986).

There are three general regions or zones of an estuary (Day et al. 1989). The tidal river zone is characterized by low-salinity water and tidal changes. The second zone is called the mixing zone, where highly saline ocean water mixes with the freshwater inflow. This zone is most commonly referred to as "the estuary" and is characterized by salt water and fresh water mixing, and the existence of strong gradients of salinity, chemical composition, and water temperature. The mixing zone extends from the tidal river zone to the river mouth. The third zone is the nearshore turbid area and occurs in the open ocean between the mixing zone and the outer edge of the river plume at low tide. The existence and size of these regions are highly dependent on surrounding landforms and geology of the coastline, water circulation, and the extent of ocean water intrusion and freshwater inflow. Freshwater inflow may be a major factor since it determines the delivery of water, sediment, and organic and other materials such as large woody material (Taylor 1992). Organic and inorganic material and sunlight are sources of energy, as in stream and river systems (Day et al. 1989). Sunlight and inorganic material increases photosynthesis by providing needed materials and organic material provides added energy produced in the estuary.

Fully functional estuaries contain water that is well mixed by saltwater exchange, freshwater inflow, and water circulation. These areas have high levels of dissolved oxygen and cool water temperatures (Taylor 1992). Mixing of salt water and fresh water creates conditions for growth of plankton and invertebrate populations. Various salinity levels in the mixing zone provide areas for acclimatization and transition to more ocean-like conditions for juvenile anadromous

fish. The existence of tidally influenced areas that are exposed to air, salt water, and fresh water for various amounts of time is important to provide conditions for chemical, physical, and nutrient processes to occur (Greeson et al. 1978). These conditions make estuaries some of the most productive and dynamic areas in terms of species diversity and abundance.

An important region of estuaries in terms of fish and wildlife requirements are the nearshore, tidally influenced and subtidal areas (Clark 1978, Odum et al. 1978). The intertidal areas of estuaries and lagoons along the Pacific Northwest coast are associated with salt marshes (Mitsch and Gosselink 1986, Day et al. 1989). Salt marshes are some of the most productive areas on earth and much of the production from salt marsh areas is transferred to the associated estuary (Mitsch and Gosselink 1986). These areas are characterized by abundant submerged vegetation and networks of stream channels, low-gradient sloughs, and tidal flats. They contain habitat components similar to stream and river systems previously discussed (Mitsch and Gosselink 1986). Components such as large woody material, cover, streamside vegetation, sediment, and water quality and quantity and the continued delivery of these components aid in providing the habitat complexity and quality that estuary organisms need to grow and persist (Odum et al. 1978).

Supply of large woody material to estuaries and ocean beach areas have decreased since the 1850s (Maser et al. 1988). Large trees and woody material play an important role in these areas. Bald eagles (*Haliaeetus leucocephalus*), great blue herons (*Ardea herodias*), green herons (*Butorides striatus*), and great egrets (*Casmerodius albus*) are some of the bird species which use large woody material as perches and stands while waiting for prey (Maser et al. 1988). While herons and egrets wade in intertidal mud flats when the water is shallow (less than 8 inches deep), eagles avoid perching on soft mud surfaces and use trees and logs away from the shore on tidal flats and on sides of estuary channels (Maser et al. 1988). Large woody material is also an important source of food, shelter and growing medium for many organisms such as plants, fungi, invertebrates, birds, fish, and mammals that use these estuary and ocean areas (Maser et al. 1988).

Pieces of large woody material deposited in intertidal areas are moved by the tides, floods and storm events, leaving depressions in the substrate. These depressions add to the habitat complexity of the intertidal area and are used by organisms such as juvenile fish for rearing areas (Maser et al. 1988). Nickelson et al. (1992) suggested that anadromous coastal cutthroat trout (*Oncorhynchus clarki clarki*) use these areas and that large woody material is an important habitat component for these fish during their estuary residence.

The coastline of Washington, Oregon, and northern California has a low shoreline-to-coastline ratio (Bottom et al. 1986) and subsequently there are fewer nearshore and well-developed estuarine areas when compared to other areas such as southeastern Alaska and British Columbia (Bottom et al. 1986) or along the Atlantic and the Gulf of Mexico coastlines of the United States (Day et al. 1989, Odum et al. 1978). This scarcity of well-developed estuaries, coupled with habitat reduction from environmental degradation due to dredging, diking, channelization, and land use practices in and near bays, estuaries, and upstream watersheds, has resulted in a reduction of habitat for resident and migratory species of fish, wildlife, and other organisms (Dahl 1990, Simenstad et al. 1982).

Wetlands System Components

Wetlands are defined in general terms as areas where inundated or saturated soils are present for a long enough period in the growing season (usually at least two or three weeks) to become the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. No universally accepted definition of wetlands exists, though definitions for regulatory purposes such as the Clean Water Act or for technical analysis such as inventory or functional assessment, all combine features of hydrology, soils (hydric soils), and vegetation (hydrophytes).

For purposes of conducting the National Wetland Inventory, the FWS has defined wetlands as:

". . . lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year" (Cowardin et al. 1979).

Hydrologic cycle. Many of the system functions of wetlands involve inundation of areas for portions of the year. These functions include flood conveyance, flood storage, sediment control, protection from storm waves and erosion, wildlife habitat, water quality improvement, recreation, and water storage during dry periods (USDA et al. 1993b). Many wildlife species and plants occurring in wetlands are specifically adapted to living in wetland conditions. Riparian and fresh water impounded wetlands have the ability to temporarily detain floodwaters and attenuate flood peaks (Wald and Schaeffer 1986). Wetlands will be most efficient at reducing downstream flooding during typical flood events and efficiency decrease during major flood events (Wald and Schaeffer 1986). But during dryer seasons, a specific wetland's ability to detain floodwaters and reduce downstream flooding or increase base stream flow depend on the physical dimensions of the wetland and its outlet, and the characteristics of the inflow flood.

Headwater reaches of drainage systems in montane regions frequently contain meadows and bogs. These areas lack forests and have seasonally varying water tables. Soils are typically sandy peats saturated nearly to the ground surface throughout the year. These meadows can intercept considerable snowfall and can increase water yield from high-elevation drainages during snowmelt (Kittredge 1948). They also can retain runoff as ground water or temporary ponds. Such ponding is less common where soils are deep, such as the coastal ranges of Oregon and California or where the bedrock is volcanic or highly fractured (the southern Cascades) (Zedler et al. 1985).

The meadows of the Pacific coast region occupy positions in the landscape such as small valleys and swales clearly representing ground water discharge zones. Some of these meadows are also likely to act as sources of recharge to shallow aquifers. This affects downslope springs and seeps. Water enters the headwater wetlands where it is temporarily stored and is steadily released at a moderate rate to lower order channels (Zedler et al. 1985).

Similar hydrologic functions can be performed by palustrine wetlands and riparian areas of lower elevations in the forests. Much of the landscape remains intact in that physical alterations such as channelization and levee construction have not occurred. These functions can be protected by intact water protection buffers of widths described in USDA et al. (1994) and

Thomas et al. (1993). Effectiveness of wetlands and riparian areas in lower floodplains has been limited by extensive hydrologic modification from levees, dikes, dams, channelization, etc.

The following is a discussion of the components of hydrologic cycles.

Water quality. The quality of runoff into wetlands and the quality of water stored in wetlands are the primary discussions in this component. Complex chemical reactions take place in many of the wetlands systems; the resulting compounds directly effect the species found there and the nutrients available to them. Wetlands filter inorganic nutrients, sediments, and organic toxicants from water flowing across them. Studies have indicated that presence of wetlands in the watershed results in decreased surface water concentrations of inorganic suspended solids, fecal coliform, nitrates, ammonium, total phosphorous, and lead (Johnston et al. 1990). For specific wetlands of the Pacific Northwest, Reinelt et al. (1990) have demonstrated that wetlands function to remove sediment and nitrates from water that enters and flows through the wetland.

Water quantity. Many wetlands are inundated for only a few weeks each year. However, the soil may remain saturated below the surface for many months. Water levels in the soil directly effect the species, especially vegetation, that survive in the wetlands. USDA et al. (1993b) states that wetlands are extremely important reservoirs for species. A large number of the wildlife in western Washington and Oregon use wetlands during part of a season or a portion of their life cycle. Often, the longer an area (wetland) is inundated the greater it's productivity that year.

Sediment. Filling of wetlands by sediment in runoff from the terrestrial landscape is the focus of this component discussion. Turbidity may effect photosynthesis, particularly of algae, and thus effect available food and possibly oxygen production. Higher levels of sediment may cover available habitat and food making it inaccessible. Researchers have documented nutrient and sediment removal by riparian and wetland areas in several situations.

The importance of wetlands in managing nonpoint source pollution is being emphasized by the Environmental Protection Agency (EPA) and state regulatory agencies (Robb 1992). Much of the basis for establishing the importance of wetlands in nonpoint source pollution, including results of current research, is published in Ecological Engineering (1992).

Plant species diversity. USDA et al. (1993b) noted that 51, 45, and 30 percent of all vascular plants in Washington, Oregon, and California, respectively, occur in wetlands. As part of the National Wetland Inventory, the FWS in cooperation with other federal agencies has prepared comprehensive lists of vascular plant species that occur in wetlands and their frequency of occurrence in wetland habitats. While the Pacific Northwest is not rich in wetlands as a percentage of the total landscape (slightly more than 2 percent in Washington and Oregon), a relatively large percentage of total plant species in the region occurs in wetlands. This is not unlike the coalescence of animal species in riparian and wetland habitats. Many of the species that occur in wetlands are found there only a small percentage of the time over their geographic range. In most cases they are associated with upland habitats. Their occurrence in wetlands could represent genetically distinct populations or even individuals (Tiner 1991) represent sources of genetic biological diversity.

Wildlife dependency and diversity peak at the terrestrial/aquatic boundary (i.e., in riparian areas and wetlands). This coalescence of species and ecological processes is becoming better documented with each scientific study. Wildlife have a disproportionately high use of riparian

zones and wetlands. Brown (1985) stated that riparian zones provide more niches than any other type of habitat.

Areas commonly accepted as wetlands include, marshes, swamps, wet meadows, and vernal pools. Marshes and swamps both have water at or above the soil surface for an extended portion of the growing season as well as vegetation, such as cattails (*Typha latifolia*) that are rooted below the water surface but have leaves in the open air. These wetlands are among those commonly found in connection with riparian areas. They also occur along the edges of lakes, ponds, and reservoirs. In colloquial conversation the distinction between these two wetland types is often unclear, but most people consider flooded wetlands without trees to be marshes, and those with trees to be swamps.

Fluctuating water tables and a lack of trees characterize wet meadows. These areas have seasonally varying water tables, but are saturated (sometimes inundated) for at least a few weeks during the growing season. Meadows are also often near riparian areas, especially in areas around stream headwaters. They typically occur in small valleys and swales that may be ground water discharge zones (USDA et al. 1993b) or montane areas where snow persists in the spring (Windell et al. 1986). Wet meadows often consist of grasses (members of the Poaceae family) and grass-like plants (members of the Cyperaceae and Juncaceae family) as well as broadleaf herbaceous plants.

Fluctuating water tables are also features of vernal pools, though hydrologic changes are more extreme and occur more quickly than in wet meadows. Vernal pools are inundated early in the growing season, but the water rapidly recedes in early summer though the soils may remain saturated. These environments are dominated by annual herbs and grasses adapted to germination and early growth under water (Skinner and Pavlik 1994). While California is well known for its unique vernal pools, they also occur in forested and nonforested habitats of Washington and Oregon.

Peatlands (bogs and fens) are generally saturated throughout the entire growing season and have peaty soils. While most wetlands in forested ecosystems are spatially and functionally associated with rivers and streams, bogs and many fens occur more or less in isolation (USDA et al. 1993b). Bogs generally have no significant inflow or outflow. They support hydrophytic vegetation adapted to acidic, nutrient-poor conditions, such as cranberry (*Vaccinium oxycoccus*), laurel (*Kalmia* spp.), and peat moss (*Sphagnum* spp.).

More abundant plant nutrients, which are often supplied by groundwater discharge, make fens different from bogs. The vegetation that results from this nutrient richness is often marsh like, including sedges (*Carex* spp.) and bulrushes (*Scirpus* spp.). The "peat" substrate consists of decomposing grasses, sedges, and bulrushes and some moss. Usually peat moss and other mosses also are present, but not those species that inhabit bogs. In the Pacific Northwest peatland habitats are typically more than 10,000 years old and often referred to as "old-growth" wetlands (USDA et al. 1993b).

Vegetated wetlands in the range of the spotted owl represent only a small portion of the landscape, perhaps as little as 1 percent (National Wetland Inventory 1990). This small segment of the landscape, however, provides habitat requirements for a disproportionately large number of plant and animal species. USDA et al. (1993b) noted that 51, 45, and 30 percent of all vascular plants in Washington, Oregon, and California, respectively, occur in wetlands. Brown (1985) reported that 359 out of 414 (87 percent) of wildlife species in western

Washington and Oregon use riparian zones or wetlands during some season or part of their life cycle. Many plants and animals are unique to specific wetland types such as the Mendocino gentian (*Gentiana setigera*), a plant that occurs mainly in peatlands and wet mountain meadows (Hickman 1994, Skinner and Pavlik 1994), and the northern red-legged frog (*Rana aurora aurora*) which breeds in small ponds, marshes, and backwaters. The role of wetlands as habitat providers for plants and animals is among 15 wetland functions summarized by the National Research Council (1992), which also include flood control, water quality enhancement, and recreation.

The significance of wetlands in the range of the spotted owl is heightened by the relative rarity of pristine wetlands. In Washington, more than a third of the state's wetlands have been lost (Dahl 1990), and 90 percent of the remaining wetlands are in a degraded state (WDW 1992). Thus, while providing habitat for the spotted owls, late-successional forests also function as reservoirs of intact wetlands.

Riparian System Components

Riparian areas are particularly dynamic portions of the landscape, yet they make up only 5 percent of the forest systems in the Pacific Northwest (Oakley et al. 1985). These areas are shaped by disturbances characteristic of upland terrestrial systems, such as fire and windthrow, as well as disturbance processes unique to stream systems, such as lateral channel erosion, peak flow, deposition by floods and debris flows. Near-stream, floodplain riparian areas may have plant communities of relatively high diversity (Gregory et al. 1991) and extensive hydrologic and nutrient cycling interactions between ground water and riparian vegetation. Riparian vegetation regulates the exchange of nutrients and material from upland forests to streams (Swanson et al. 1982, Gregory et al. 1991). The linkage between aquatic and riparian areas is complex. Changes in the riparian area quickly affect the biological communities of the aquatic areas. Because of this complex relationship, management of the riparian area is critical to the quality and quantity of associated aquatic systems (Gregory et al. 1991).

Fully functional forest riparian systems in the Pacific Northwest usually have the following characteristics (Oakley et al. 1985):

Habitat. Habitat has four major components: cover, food, and water and their arrangement in the landscape. The usefulness of a habitat depends on whether the components of the habitat meet the needs of the organisms. If the habitat does not fulfill the organisms' needs, the organisms will move to an area that provides for those needs and allows the organisms to flourish or the organisms perish. Many species are endemic to riparian areas of the Pacific Northwest (Johnson and Lowe 1985).

Riparian vegetation. Large conifers or a mixture of large conifers and hardwoods are found in riparian zones along all streams in a watershed, including those not inhabited by fish (Naiman et al. 1992). Riparian zone-stream interactions are a major determinant of large woody material accumulation in streams next to riparian areas (House and Boehne 1987, Bisson et al. 1987, Sullivan et al. 1987). Large woody material is used as substrates for growth of colonies, sources of food organisms, and sources of shelter and nest sites by many species inhabiting riparian areas.

Large logs and root wads in riparian areas are used as nesting sites for ducks (Cassirer et al. 1993). Streambanks are vegetated with shrubs and other low-growing woody vegetation. Root systems in streambanks of the active channel stabilize banks, allow development and maintenance of undercut banks, and protect banks during large storm flows (Sedell and Beschta 1991). Riparian vegetation contributes leaves, twigs, and other forms of fine lítter that are an important component of the aquatic system food base (Vannote et al. 1980). Riparian vegetation is the most effective means of controlling sediment before it is introduced to streams (Megahan 1984, Heede et al. 1988). Maintaining the integrity and the complexity of riparian vegetation is particularly important for riparian-dependent organisms such as amphibians, arthropods, mammals (including bats), and birds.

Shape. Riparian areas generally have an irregular shape with "edges" where the riparian areas meet either the terrestrial or aquatic system. This irregular shape provides a high ratio of edge-to-surface area, allowing considerable interaction among terrestrial, riparian, and aquatic systems. This edge effect allows habitat complexity, species richness, and material and energy transfer to occur throughout the watershed and operate at different levels to meet the needs of the systems.

Microclimate. The climate in riparian areas is different from the surrounding, usually drier, coniferous forests due to the increased rate of transpiration, higher humidity, and greater air movement. This distinct microclimate is maintained along stream channels, created by cold air drainage and the presence of turbulent surface waters. Riparian vegetation and this cool, humid climate are used by wildlife as thermal cover during summer and as shelter areas during winter. Riparian vegetation moderates stream temperatures and light levels that influence ecological processes (Agee 1988, Gregory et al. 1991).

Travel routes. Riparian systems serve as a natural travel or dispersal route for some species. Riparian and streamside vegetation provides cover and food that can be important during migration and dispersal of organisms from home ranges (Johnson and Lowe 1985).

Aquatic habitats. Riparian areas also contribute to productive fish and aquatic organism habitats that are made up of good water quality, suitable water temperatures, substrates for aquatic organism growth and a variety of habitat components that are arranged to fulfill the needs of the organisms throughout various life stages and allow them to persist.

Riparian habitat conditions within the range of the northern spotted owl have been degraded by road construction and land management activities. For example, Coast Range riparian areas outside of wilderness areas in Washington and Oregon have been simplified to tree species such as red alder (*Alnus rubra*) because of timber harvest and associated activities that removed marketable timber down to the stream margins (Oliver and Hinckley 1987). These tree species are less suitable than conifers as sources of large woody material due to shorter decomposition time and smaller wood mass (Triska et al. 1982, Grette 1985). Riparian areas in many managed forestlands have few trees larger than 10 inches in diameter growing within 100 to 200 feet of streams. The removal of large conifers and the scarcity of a source of large woody material near streams suggest that streamside recruitment of large woody material may be deficient for decades.

Riparian Processes as a Function of Distance From Stream Channels

Many effects of riparian vegetation on streams decrease with increasing distance from the streambank (Figures A.1 and A.2) (Van Sickle and Gregory 1990, McDade et al. 1990, Beschta et al. 1987) and are influenced by the degree of channel constraint and flood plain development (Sparks et al. 1990, Sedell et al. 1989). The following processes are affected by the distance from stream channels (adapted from USDA et al. 1993).

Root strength. The upstream head of steep channels and other steep hillside areas are common initiation sites of debris slides and debris flows (Dietrich and Dunne 1978). Root strength provided by trees and shrubs contributes to slope stability, and the loss of root strength following tree death by timber harvest or other causes may lead to increased incidence of debris slides and debris flows (Sidle et al. 1985). The soil stabilizing zone of influence for vegetation in these sites is the slide scar width plus half a tree crown diameter. Half a tree crown diameter is an estimate of the extent that root systems of trees adjacent to the slide scar margin affect soil stability. The contribution of root strength to maintaining streambank integrity also declines at distances greater than one-half of a tree crown diameter (Figure A.1) (Burroughs and Thomas 1977, Wu 1986).

Large woody material delivery to streams. The probability that a falling tree will enter a stream is a function of slope distance from the channel in relation to tree height (Van Sickle and Gregory 1990, McDade et al. 1990, Andrus and Lorenzen 1992). The effectiveness of floodplain riparian forests and riparian forests along constrained channels to deliver large woody material is low at distances greater than approximately one tree height away from the channel (Figure A.1).

Large woody material delivery to riparian areas. Large down logs, root wads, and limbs are recruited into riparian areas from the riparian forests and from upslope forests (Figure A.1). Similar to large woody material delivery from riparian areas into streams, the effectiveness of upland forests to deliver large woody material to the riparian area is naturally expected to decline at distances greater than approximately one tree height from the stand edge (Thomas et al. 1993). Timber harvest adjacent to the riparian area creates an edge that eliminates one source of large woody material, and long-term levels of large woody material may diminish in the riparian area.

Leaf and other particulate organic material input. The distance from the source of leaf litter to the stream depends on site-specific conditions. The effectiveness of floodplain riparian forests to deliver leaf and other particulate organic material declines at distances more than approximately one-half a tree height away from the channel (Figure A.1). When this document was written it was unknown if there were studies that examined litter fall from riparian areas as a function of distance of litter source from the channel. However, Erman et al. (1977) reported that the composition of benthic invertebrate communities in streams with riparian buffers wider than 100 feet were indistinguishable from those in streams flowing through unlogged watersheds. While other factors could have influenced community structure, riparian forests wider than or equal to 100 feet retained sufficient litter inputs to maintain biotic community structures in the stream examined.

Shade. Effectiveness of streamside forests to provide shade varies with topography, channel orientation, extent of canopy opening above the channel, and forest structure, particularly the extent of the understory and the overstory. Although, any curve depicting this function is by

necessity quite generalized, buffer width correlates well with degree of shade (Figure A.1) (Beschta et al. 1987). the Oregon Coast Range and western Cascade Range full retention of all vegetation within 100 feet of streams is needed to maintain as much natural shade condition as undisturbed late-successional forests (Beschta 1987).

Riparian microclimate. Streamside and upslope forests affect microclimate and habitat in riparian systems. Microclimate is likely to be influenced by widths of both riparian areas and stream channel. Riparian areas along larger streams, third-order streams and larger, consist of two distinct parallel bands of vegetation separated by the stream channel. By contrast, channels of lower-order streams are so narrow that a functionally continuous canopy usually exists.

When this document was written, it was unknown if there were reported field observations of microclimate in riparian areas, but Chen (1991) documented changes in soil and air temperature, soil moisture, relative humidity, wind speed, and radiation as a function of distance from a clear-cut edge into upslope forest in two Cascade Range study sites. Patterns vary substantially with season, time of day, edge aspect, and extent of tree removal in the harvested stand. Figure A.2 shows the maximum effects observed by Chen (1991).

Riparian Area Protection

When timber is harvested to the outer limit of the riparian area, an edge is created that may affect the interior microclimatic conditions of the riparian forest. If the forest is harvested from only one side of a small stream, leaving both riparian areas intact, then the edge effect on the microclimatic conditions within the riparian forest may be comparable to those demonstrated in upland forests. Removing upland forests from both sides of the riparian zone of a small stream creates two edges and the effect on microclimatic conditions may be additive, if not synergistic (USDA et al. 1993). The degree to which the two edge effects are additive depends on the total width of the riparian corridor and is probably influenced by season, time of day, aspect, channel orientation, and extent of tree removal from the harvested stand. This situation is somewhat analogous to harvesting the forest adjacent to the riparian area along a larger river. When this forest is removed, the riparian area of a larger river becomes a corridor with two edges, one created by the river channel itself and one resulting from timber harvest. Buffers may need to be wider to maintain interior microclimatic conditions.

Castelle et al. (1992) provided a thorough literature review of widths of riparian areas required to protect water quality functions. In general, USDA et al. (1993) found that widths of riparian areas required to protect water quality ranged from 12 to 860 feet. Widths varied as a function of characteristics such as slope and soil type and by vegetative structure and cover. Effectiveness of buffers at improving water quality adjacent to logging operations was studied by Broderson (1973), Darling et al. (1982), Lynch et al. (1985), and Corbett and Lynch (1985). Broderson studied three watersheds in western Washington and found that 200-foot buffers, or about one site-potential tree height, would be effective to remove sediment in most situations if the buffer were measured from the edge of the flood plain. The Washington Department of Wildlife (WDW) (1992) recommended wetlands buffer widths for protection of wildlife species in that state. Roderick and Milner (1991) also prescribed wildlife protection buffer requirements for wetlands and riparian habitats in Washington. These widths vary from 100 to 600 feet depending on species and habitat usage.

Erman and Mahoney (1983) studied aquatic invertebrate diversity in streams of northern California where the riparian area was natural, logged and protected by a buffer strip. They found six to 10 years after logging that narrow buffers (less than 100 feet) were not effective in promoting a more complete recovery of stream invertebrate diversity than streams without bufferstrips. They concluded that unless logging is carefully conducted, buffers less than 100 feet are inadequate to protect the stream and that buffers less than 100 feet wide do not enhance recovery compared to unbuffered streams.

Factors and Indicators to Assess Aquatic-riparian System and Watershed Function

Through recent efforts to aid watershed analysis (USDA et al. 1993) and provide a basis for assessing how aquatic riparian systems and watersheds are functioning in relation to the proposed listed fish populations in southwestern Oregon, biologists from NMFS, BLM, and Forest Service (Dose 1996, Frick 1996) have developed a set of matrices for several physiographic regions (Tables A-1, A-2, A-3). These matrices should provide a framework and foundation, in absence of basin or watershed specific information, to help land management agency and regulatory agency biologists determine effects of proposed actions within river basins where proposed or listed fish species occur. This set of matrices should also aid in identifying restoration opportunities at the watershed scale.

Summary of Effects of Natural Disturbances and Human Activities on Aquatic and Riparian Species

Forestry, agriculture, and urbanization and their associated actions have changed the shape and appearance of watersheds and reduced important habitat characteristics and structure, such as large woody material and streambank vegetation (Li et al. 1987). These activities have varying degrees of impact on the aquatic habitats and associated biological communities in streams, rivers, lakes, ponds, marshes, bogs, estuaries, and lagoons in the Pacific Northwest.

This appendix has reviewed the various impacts of forest practices, road building, agricultural practices, and urbanization on watershed and aquatic habitat quality and the resulting effects on organisms in these areas, and more specifically on native resident and anadromous fish, and amphibian productivity. These impacts include increased stream temperature and light, reduced dissolved oxygen, altered streamflow patterns, increased sedimentation, decreased supply of large woody material, increased possibility of migration obstacles, loss of , streamside vegetation, and loss of habitat complexity. The recovery of riparian areas, fish habitat, and water quality may require 25 to 200 years (Gregory and Ashkenas. New disturbances, probably would add to the watershed degradation. USDA et al. (1993) and USDA et al. (1994) have stated that many watersheds will require 100 to 200 years to recover from past actions. Many endangered, threatened, or at risk species may not persist given that time frame for watershed recovery (Rhodes 1994).

The common threads through these discussions have been the impacts on water quality and habitat complexity throughout the watersheds. As stated earlier, these two factors are major reasons for the decline of native fish and other aquatic and riparian organisms in the Pacific Northwest, and they are tied to the quality of the riparian vegetation associated with the stream.

All aquatic species need high levels of water quality and habitat complexity existing throughout the watershed.

This appendix also has discussed how various upland, riparian, stream, wetland, estuary, and ocean systems are connected. This connection provides for the flow of species, energy, and materials through these systems and allows for the cycling of physical, chemical, and biological components. A breakdown of any one of these systems, thereby impacting associated ecological cycles, results in stresses in the interconnected systems that show up as diseases and changes in population traits and in abundance of organisms that humans have come to rely on for economic, social, and cultural benefits. To maintain these connections, functions, and biological communities, water quality, habitat complexity, and biological components must extend throughout the watershed.

Hicks et al. (1991) provided the following recommendations for planning timber harvest activities to minimize the impacts of these activities on the fisheries and riparian resources of the affected area. These recommendations would also benefit other organisms such as amphibians, birds, mammals, insects, and other aquatic- and riparian-dependent species.
(1) Leave streamside vegetation intact to protect the streamside area. This will help maintain the integrity of channels and protect the stream-riparian interactions.
(2) Promote conditions of moderate temperatures, low to moderate sediment levels, high light levels, adequate nutrient levels, abundant cover, and a diversity of habitat and substrate types to enhance productivity of streams for salmonid production.
(3) Protect floodplain and side-channel habitats.
(4) Protect streams from frequent and excessive episodes of bed-load movement or sediment deposition. This is done by streamside management and proper planning and placement of roads and timber removal systems.
(5) Manage streamside areas to provide recruitment of large woody material into the stream and to protect existing large woody material.
(6) Consider the climate and landforms present in the watershed. The climate, geology, and characteristics of the specific watershed can affect the response of the fisheries resources to the timber practices used.

Meehan (1991) stressed that the protection of aquatic habitats should be the primary goal of resource managers and the best protection is preservation of watersheds, rather than restoration or mitigation of watershed impacts. This view is shared by Bielak (1992) and Meyer (1992). Bisson et al. (1992) pointed out that restoration efforts can rebuild habitat diversity, but that costs often limit the restoration efforts to certain stream reaches rather than the entire basin. In this case, Meehan's (1991) advice of protecting and preserving existing stream habitat and the associated riparian areas rather than restoring habitat after land-use activities have damaged it seems to be a prudent and cost effective way to manage the resources in a given watershed.

Table A- 1: Matrix of Factors and Indicators Western Cascades Physiographic Region

FACTORS	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Water Quality	Temperature (7 day max. ave.)	2nd-3rd order basin: <58 F. 4th + basins: <65 F.	2nd-3rd order: 59-65 F. 4th + order: 66-72 F.	2nd-3rd order: >65 F. 4th + order: >72 F.
	Sediment/Turbidity[1]	<12%fines (<0.85mm) in gravel, turbidity low, or cobble embeddedness <35%.	12-17% fines (<0.85mm) in gravel.	>17% fines (<-.85mm) in gravels, tubidity high, or cobble embeddedness >35%.
	Chemical Contaminants/ Nutrients	Low levels of chemical contaminants from agricultural, industrial and other sources, no excess nutrients, no CWA 303d designated reaches.		Mod. + levels of chemical contamination from agricultural, industrial and other sources, any level of excess nutrients, one or more CWA 303d designated reaches.
Habitat Access	Physical barriers	All human-made facilities in the watershed allow upstream and downstream fish passage at all flows for age 1+ salmonids.		Any human-made facilities in the watershed do not allow upstream and/ or downstream fish passage at all flow ranges for age 1+ salmonids.
Habitat Elements	Substrate[1]	Dominant substrate is gravel or cobble (interstitial spaces clear, embeddedness <35%).	Gravel and/or cobble is sub-dominant.	Bedrock, sand, silt, or small gravel dominant, or if gravel and cobble dominant, embeddedness >35%.
	Large Woody Material	>60 pieces/mile, >24" diam. & 50 ' in length. Adequate sources of future LWM to maintain the above standard. Little evidence of stream clean-out or management related debris flows.	30-60 pieces/mile, >24" & >50 ' in length or lacks potential sources of LWM sufficient to maintain or achieve the fully functioning standard.	<30 pieces/mile, >24" and >50' long and lacks potential sources of LWM. Evidence of stream clean-out and/or management related debris flows.
	Pool Characteristics [1,2]	>30% pool habitat by area. Little reduction in pool volume due to filling by fine sediment or unsorted substrates.	>30% pool habitat by area but with obvious filling by fines or unsorted substrates Or <30% pool habitat by area and little reduction in pool volume due to filling.	<30% pool habitat by area and obvious reduction in pool volume due to filling with fines and/or unsorted substrates.

[1]Numeric values for these elements will be determined by measurements or estimates taken in low-gradient (<3%), adjustable segments. These elements may not be applicable if none are present 1990).

[2]Pool characteristic numerics are applicable to 3rd order or larger basins.

FACTORS	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
	Refugia (Important remnant habitat for sensitive aquatic species)	Habitat refugia exist and are adequately buffered (e.g. by intact riparian reserves); existing refugia are sufficient in size, number and connectivity to maintain viable populations or sub-populations.	Habitat refugia exist but are not adequately buffered (e.g. by intact riparian reserves); existing refugia are insufficient in size, number and connectivity to maintain viable populations or sub-populations.	Adequate habitat refugia do not exist.
Channel Condition and Dynamics	Width/Depth Ratio	W/D ratio and channel types are within historic ranges and site potential as per Rosgen typing.	Evidence of downcutting, widening or aggradation. Trend away from site potential.	W/D ratios and channel types are outside historic ranges and site potentials.
	Streambank Condition [1]	Basinwide, in low gradient reaches, >90% stable; i.e., on average, less than 10% of banks are actively eroding.	Basinwide, in low gradient reaches, stream banks 80-90% stable. Active erosion limited to outcurves	<80% of streambanks are stable. Active erosion widespread throughout basin in low gradient reaches.
	Floodplain Connectivity [1]	Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.		Obvious reduction in hydrologic connectivity between off-channel, wetland, floodplain and riparian areas; wetland extent noticeably reduced and riparian vegetation/succession altered significantly.
Flow/Hydrology	Drainage Network/Peak Flow Changes	Little increase in drainage network due to roads.		Substantial increases in drainage network density due to roads (e.g., -20-35%)
Watershed Conditions	Road Density & Location	<2mi/mi square, with no valley bottom roads.	2-3 mi/mi square, with some valley bottom roads.	>3mi/mi square and/or substantial amount of valley bottom roads.
	Disturbance History	<5% ECA/decade (entire watershed) with no concentration of disturbance in unstable or potentially unstable area, and/or refugia, and/or riparian reserves		>5% ECA/decade (entire watershed) and disturbance concentrated in unstable or potentially unstable areas, and/or refugia, and/or riparian reserves.
	Riparian Reserves	Riparian Reserves are intact, with >80% in late seral conditions.		Riparian Reserves are fragmented, poorly connected or provide inadequate protection of habitats and refugia for sensitive aquatic species. <80% are in late seral condition.
	Management Related Landslide Rates	0-15% of historic natural rates. Stream conditions not evidently altered due to management related landslides.	>15% of natural rates with light alteration of stream conditions due to management related landslides.	>15% of historic natural rates. Stream conditions obviously altered by management related landslides.

Table A- 2: Matrix of Factors and Indicators High Cascades Physiographic Region

FACTORS	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Water Quality	Temperature (7 day max. ave.)	2nd-3rd order basins: <52 F. 4th + basins: <55 F.	2nd-3rd order: 52-55 F. 4th + order 55-58 F.	2nd-3rd order: >55 F. 4th + order: >58 F.
	Sediment/Turbidity[3]	<12% fines (<0.85mm) in gravel, turbidity low, or cobble imbeddedness <35%.	12-17% fines (<0.85mm) in gravel.	>17% fines (<0.85mm) in gravel, turbidity high, or cobble embeddedness > 35%.
	Chemical Contaminants/ Nutrients	Low levels of chemical contaminants from agricultural, industrial and other sources, no excess nutrients, no CWA 303d designated reaches.		Mod. + levels of chemical contamination from agricultural, industrial and other sources, any level of excess nutrients, one or more CWA 303d designated reaches.
Habitat Access	Physical Barriers	All human-made faciliities in the watershed allow upstream and downstream fish passage at all flows for age 1+ salmonids.		Any human-made facilities in the watershed that do not allow upstream and/or downstream fish passage at all flow ranges for age 1+ salmonids.
Habitat Elements	Substrate[3]	Dominant substrate is gravel or cobble (interstitial spaces clear, embeddedness <35%).	Gravel and/or cobble is sub-dominant.	Bedrock, sand, silt, or small gravel dominant or if gravel and cobble dominant, embeddedness > 35%.
	Large Woody Material[4]	>30 pieces/mile, >12" diam. and >35' long. Adequate sources of future LWM to maintain the above standard. Little evidence of stream clean-out or management related debris flows.	20-30 pieces/mile, >12" and >35' long or lacks potential sources of LWM sufficient to maintain or achieve the fully functioning standard.	<20 pieces/mile, >12" and >35' long and lacks the potential sources of LWM. Evidence of stream clean-out and/or management related debris flows.
	Pool Characteristics[5]	>30% pool habitat by area. Little reduction in pool volume due to filling by fine sediment or unsorted substrates.	>30% pool habitat by area but with obvious filling by fines or unsorted substrates or <30% pool habitat by area and little reduction in pool due to filling.	<30% pool habitat by area and obvious reduction in pool volume due to filling with fines and/or unsorted substrates.

[3]Numeric values for these elements will be determined by measurements or estimates taken in low-gradient (<3%), adjustable segments. These elements may no be applicable if none are present.

[4]LWM numerics are not applicable in meadow reaches.

[5]Pool characteristic numerics are applicable to 3rd order or larger basins.

FACTORS	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
	Refugia (important remnant habitat for sensitive aquatic species)	Habitat refugia exist and are adequately buffered (e.g. by intact riparian reserves); existing refugia are sufficient in size, number and connectivity to maintain viable populations or sub-populations.	Habitat refugia exist but are not adequately buffered (e.g. by intact riparian reserves); existing refugia are insufficient in size, number and connectivity to maintain viable populations or sub-populations.	Adequate habitat refugia do not exist.
Channel Conditions and Dynamics	Width/Depth Ratio	W/D ratio and channel types are within historic ranges and site potential as per Rosgen typing.	Evidence of down cutting, widening, or aggradation. Trend away from site potential.	W/D ratios and channel types are outside of historic ranges and site potentials.
	Streambank Condition [3]	Basinwide, in low gradient reaches, >90% stable; i.e., on average, less than 10% of banks are actively eroding.	Basinwide, in low gradient reaches, stream banks 80-90% stable. Active erosion limited to outcurves.	<80% of streambanks are stable. Active erosion wide spread throughout basin in low gradient reaches.
	Floodplain Connectivity [3]	Off-channel areas are frequently hydrologically linked to main channel; overbank flows occur and maintain wetland functions, riparian vegetation and succession.		Obvious reduction in hydrologic connectivity between off-channel, wetland, floodplain areas; wetland extent noticeably reduced and riparian vegetation/succession altered significantly.
Flow/Hydrology	Drainage Network/ Peak Flow Changes	Little increase in drainage network due to roads.		Substantial increases in drainage n network density due to roads (e.g., 20-25%)
Watershed Conditions	Road Density & Location	<2 mi/mi square, with no valley bottom roads	2-3 mi/mi square, with some valley bottom roads.	>3 mi/mi square and/or substantial amount of valley bottom roads.
	Disturbance History	<5% ECA/decade (entire watershed) with no concentration of disturbance in unstable or potentially unstable areas, and/or refugia, and/or riparian reserves.		>5% ECA/decade (entire watershed) and disturbance concentrated in unstable or potentially unstable areas and/or refugia, and/or riparian reserves.
	Riparian Reserves	Riparian Reserves are intact, with >80% in late seral condition.		Riparian Reserves are fragmented , poorly connected or provide inadequate protection of habitats and refugia for sensitive aquatic species. (80% are in late seral condition.)
	Management Related Landslide Rates	0-15% of historic natural rates. Stream conditions no evidently altered due to management related landslides	>15% of natural rates with slight alteration of stream conditions due to management related landslides.	>15% of historic natural rates. Stream conditions obviously altered by management related landslides.

Table A- 3: Matrix of Factors and Indicators Klamath Province/Siskiyou Mountain Physiographic Region

FACTORS	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
Water Quality	Temperature (7 day max. ave.)	<64 F. or within the expected temperature range.		64 F.; or above expected temperature range.
Habitat Access	Physical Barriers	No human-made barriers to prevent passage of juvenile and adult salmonids to historic habitat.		Human-made barriers prevent upstream and downstream passage of salmonids.
Habitat Elements (focus on conditions in low gradient, fish-bearing stream segments (LGS), usually alluviated canyons or alluvial valleys - Frissell, 1986, 1992)	Sediment	<20% fines (sand, silt, clay) in gravel , little cobble embeddedness. Fine sediment within range of expected natural streambed conditions.		>20% fines (sand, silt, clay) in gravel, embedded cobbles. Fine sediment outside of expected natural streambed conditions.
	Large Wood Material (LGS)	>25 pieces/mile (Siskiyou east), >40 pieces per mile (Siskiyou west); >24" in diameter and >50 ' long or 2X bankful width (BFW) or within expected range. Little evidence of stream clean-out.		<10 (east), <25(west) pieces/mile >24" diam. and >50' long or 2X BFW. Evidence of stream clean-out or outside of expected range of conditions.
	Pool Character and Quality (LGS)	>30% pool habitat by area; little evidence of pool volume reduction and majority of pools > 3 ' deep.		<30% pool habitat by area; widespread evidence of pool volume reduction and majority of pools < 3 ' deep.
	Off-Channel Habitat (LGS)	Active side channels relatively frequent; backwater areas present; related to large wood, nick point, etc. or within the expected range of natural conditions.		Few or no active side channels or backwater areas. Entrenchment or evidence of abandonment of floodplain. Side channel frequency outside of range expected.
Channel Conditions and Dynamics	Width Depth Ratios by Channel Types	[6]W/D ratios and channel types within historic ranges and site potential within watershed. (As per Rosgen typing)		[1]W/D ratios and channel types throughout the watershed are well outside of historic ranges and/or site potential.

[6]Expected range of bankfull width/depth ratios and channel types

Rosgen Type	W/D Ratio
A, E, G	<12
B, C, F	12-30
D	>40

FACTORS	INDICATORS	PROPERLY FUNCTIONING	AT RISK	NOT PROPERLY FUNCTIONING
	Streambank Condition	Stable stream banks, little evidence of eroding banks or within range of expected conditions.		Unstable stream banks, numerous areas of exposed soil and cutting, outside of expected range.
	Floodplain Connectivity (LGS)	Off-channel areas frequently linked to main channel, floods frequently connect stream to floodplain and riparian zone.		Greatly reduced connectivity between main channel and off-channel habitats and riparian areas.
Flow/Hydrology	Changes in Peak Flows (consider effects at watershed scale)	Timber harvest, roads and other human activities have not likely influenced the hydrologic regime of the watershed. Little extension of channel network.		High levels of timber harvest and roads have likely effected the hydrologic regime of the watershed. Considerable increase in channel network.
Watershed Conditions	Road Density and Location	Low road densities (use <2mi./mi. sq. for reference), valley bottom roads not restricting stream meanders or affecting riparian function.		High road densities (use >3 mi./mi.sq. for reference), valley bottoms well-roaded, affects stream channel and riparian function are evident.
	Human Disturbance History (within area tributary to fish-bearing stream segment)	Little harvest and road activity, with no concentration in unstable areas, aquatic and riparian refugia or riparian reserves.		Widespread harvest and road activity with disturbance concentrated in unstable areas, refugia or riparian reserves.
	Riparian Reserves	Riparian reserves provide adequate shade, future large wood, habitat protection and connectivity for sensitive aquatic species. Little or no evidence of salvage, sufficient down wood or within expected range of conditions.		Substantially altered riparian reserves, not providing adequate shad, habitat protection and connectivity for sensitive aquatic species. Extensive salvage and down wood lacking or outside of expected range of conditions.
	Landslide and Erosion Rates	Landslide rate and volume near natural rates. Stream conditions not altered by human-caused landslides.		Landslides exceed natural rates and related to land management activities. Stream conditions obviously altered by human activities.

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APPENDIX B: FISH LIFE HISTORY AND STOCK STATUS

Key Terms:

Alevin - A newly hatched salmonid that has not emerged from the redd.

Anadromous fish - A fish born in fresh water, migrates to the ocean or estuary to grow and mature, then returns to fresh water to spawn.

Escapement - The portion of an anadromous fish population that escapes fisheries and/or natural mortalities and returns to the freshwater spawning areas.

Fry - A young fish, here referring to a juvenile salmonid that has emerged from the redd.

Mainstem river - The portion of the river containing the main channel or major portion of the water flow.

Native fish - Species present in the area prior to 1800 as a result of evolutionary dispersal.

Oxbows and meanders (side channels) - River or stream channels characterized by slower water velocity, may not always be connected to the main channel of the stream or river.

Redd - An gravel nest in the water, dug by fish to deposit eggs.

Resident fish - A fish born in fresh water, does not enter saltwater environments, but may migrate a long distance to feed or spawn.

Salmonid - A member of the family Salmonidae, which includes trout, salmon, char, and whitefish.

Introduction

Several species of fish are native to the streams, rivers, lakes, and estuaries of southwestern Oregon within the range of the northern spotted owl (*Strix occidentalis caurina*). This fish assemblage includes anadromous fish, examples are salmon and steelhead trout (*Oncorhynchus* spp.), and resident fresh water fish, examples are sculpins (*Cottus* spp.) and suckers (*Catostomus* spp.). These fish have developed unique characteristics and life history strategies to survive in the habitats in the springs, streams, rivers, lakes, and marine environment of the Pacific Northwest (see Appendix A).

Native fish species have cultural, social, economic, and historical significance to the people of the region (Smith 1994). The Indians of the Pacific Northwest have depended on the fish resources as food, barter, and a religious base for their culture. The immigrants and settlers used the fish resources for food and later as a base for economic development of the region. The most significant species were the various salmon and steelhead trout stocks. This resource, along with the abundant forests, provided economic opportunities that drew more and more people to the region.

As the human population of the Pacific Northwest grew and its natural resources were exploited, concerns were raised about the decline in population size of some of the fish species and the loss of aquatic habitats. The concerns usually focused on the anadromous fish species (salmon and steelhead trout) of commercial and recreational interest and were based on reduced harvest levels. Harvest regulations became more restrictive and harvest allocations between fisheries grew smaller to spread the diminishing harvest between tribal, recreational, and commercial interests.

Hatcheries were constructed as mitigation for lost habitat and fish production caused by dam construction. Hatcheries were also built as mitigation for other habitat modification or loss. In some cases this mitigation action resulted in short term increases in harvest. But, concerns about hatchery impacts on wild fish and continued harvest of depressed wild populations were also voiced (Nehlsen et al. 1991, Nickelsen et al. 1992). Only recently has attention been given to restoring and conserving remaining habitat for wild populations (Frisell et al. 1992).

Since 1976 several Federal acts have regulated harvest and promoted restoration of the anadromous salmonids and their associated habitats in the Pacific Northwest. These include the Magnuson Fisheries Conservation and Management Act, Public Law 94-265; the United States-Canada Pacific Salmon Interception Treaty, Treaty Document No. 99-2, and the Pacific Salmon Treaty Act, Public Law 99-5; and the Northwest Power Act, Public Law 96-501.

These federal actions have usually been in response to a crisis situation (depleted population levels, decrease in fish harvest levels) or the possible recolonization of lost habitat rather than as plans to avoid future problems. The scope of these actions is often a single species or similar group of species (e.g. salmon and steelhead trout) rather than an entire ecosystem or fish community perspective. Only recently have discussions and actions focused on larger level (watershed or river basin) needs and often time these actions have attempted to address one impact (e.g. harvest or habitat issues) rather than encompassing all activities contributing to the problem (Frisell et al. 1993). The time frame involved in these actions may limit their effectiveness in providing meaningful levels of restoration. Restoration of populations of anadromous salmonids may take several years or decades (Bisson et al. 1992). Bisson et al. (1992) referred to the Fraser River (Canada) sockeye population gradually rebuilding to historical levels by the late 1980s after restoration efforts in the 1940s.

At the same time, decreases in non anadromous fish species that do not possess interest as a commercial or recreational species have occurred. Decline in numbers of these species is hard to detect since there is no harvest data and there has been little incentive to gather information concerning distribution, status of local populations, and habitat requirements (Bisson et al. 1992). These species may be more sensitive to changes in the freshwater habitats than anadromous fish since they spend their entire lives in the freshwater environment. Declines in fish and other aquatic species that are not harvested by humans point toward other reasons for their decline, such as habitat loss and degradation. Decline of an assemblage of species in an area is a sign of ecological stress and ecosystem breakdown (Odum 1985, Rapport et al. 1985, see Appendix A).

The general reasons for declines in fish population are habitat loss and degradation due to water diversions, timber harvest, livestock grazing and other land use practices, overfishing, and introduction of nonnative fish and/or hatchery fish (Williams et al. 1989, Moyle and Williams 1990, Nehlsen et al. 1991). Freshwater habitat degradation and loss are the most frequent factors linked to the decline of these species (Nehlsen et al. 1991). Major concerns are

fragmentation of freshwater habitat into isolated patches and decreases in the quality and quantity of available habitat. Bisson et al. (1987) reviewed several studies that associated declines in fish abundance with the loss of pools and large woody debris (see Appendix A). Hicks (1990) suggested that salmonid diversity would be more likely to return to pre-timber harvest levels in basins dominated by basalt rock when compared to basins dominated by sandstone. Hicks (1990) found that streams in basalt rock basins contained coarser substrate, were more complex, and more resistant to summer low flows that streams in sandstone dominated basins.

Quality of freshwater habitat is just one aspect affecting the complex life history strategies of anadromous fish. Estuary and ocean environments also affect the survival chances of these species and provide them with opportunities for growth and development that are not found in freshwater environments (Dadswell et al. 1987).

Estuaries are considered important transition areas for juvenile anadromous fish while nearshore ocean areas are important to early ocean survival of these fish (Dadswell et al. 1987) (see anadromous fish section and Appendix A). Species such as chinook (*O. tshawytscha*), and anadromous coastal cutthroat trout (*O. clarki clarki*) depend on estuarine conditions to prepare for ocean entry and as feeding and transition areas (Groot and Margolis 1991, Day et al. 1989, Healey 1982). Returning adults also use estuaries as staging areas to prepare for upstream migration and spawning (Groot and Margolis 1991, Day et al. 1989). A well-developed estuary containing features needed by these species aids in meeting life history and survival requirements. The coastline of Oregon, and northern California is considered lacking in well-developed estuaries (USDA et al. 1993, Bottom et al. 1986) compared to other coastlines in the United States and Canada. Contributing to the scarcity of nearshore ocean and estuary conditions is the degradation of estuary and coastal wetland habitats in the region (Dahl 1990).

The ocean conditions adjacent to Oregon, and northern California are highly variable in terms of food availability and other habitat components from year to year because of the transition zone between ocean currents in this area of the Pacific Ocean (Bottom et al. 1986) (see Ocean distribution, rearing and feeding in this chapter). Upwelling, water temperature, and other conditions can contribute to or deter an organism's growth and ultimate survival, especially juvenile fish recently arrived in the marine environment.

Reduction in the quantity and quality of estuaries and yearly variations in ocean conditions may place more importance on the freshwater habitats to allow these anadromous salmonids to compensate for the less-than-optimum conditions in the marine environment (USDA et al. 1993). It should also be stressed that several of these species are at the southern edge of their range, which may make them more susceptible to climate change, habitat loss, and other disturbances, human and nature caused.

The American Fisheries Society (AFS) list of native fish species in decline (Williams et al. 1989) recommended 364 fish taxa in need of protection because of their rarity. This list did not include distinct stocks of anadromous fish (including Pacific salmon). A later AFS article listed Pacific salmon species in decline (Nehlsen et al. 1991) and documented the status of more than 200 populations of anadromous salmonids in need of management consideration due to declining numbers and disappearing habitat. Various surveys conducted by state and tribal fish and wildlife agencies and the AFS (Frissell 1993, Higgins et al. 1992, Nickelson et al. 1992) have been completed since those two AFS articles were published. These surveys

substantiate the earlier AFS concerns for anadromous salmonids in most cases and further divided these species into more distinct populations for management considerations. Frissell (1993) used this information to develop maps depicting region-wide patterns of anadromous and resident fish species decline. This work shows a major trend of increasing endangerment from north to south. USDA et al. (1993) estimated that 314 anadromous salmonid populations were at risk within the range of the northern spotted owl. The Lost River sucker and shortnose sucker in the upper Klamath River drainage, Oregon chub in the Willamette River system, Sacramento River winter chinook salmon, Snake River spring/summer and fall chinook salmon, Snake River sockeye salmon, and Umpqua River cutthroat trout have been listed under the federal Endangered Species Act (ESA). In addition, coho salmon and Klamath Mountain Province steehead have been proposed for listing under the ESA. These actions have elevated the concern and interest in the status of these fish species, both resident and anadromous.

The listing of species and concern about other populations in decline also elevate the concern about ecosystems and areas where several species may be declining and in danger of extinction or extirpation. Areas such as the upper Klamath River Basin of southern Oregon and northern California, the Umpqua and Rogue river basins of southwestern Oregon; and the Columbia River Basin of Washington, Oregon, Idaho and Montana, have several fish species in decline (Frissell 1993). This clustering of depressed populations is an indication of river systems and their ecosystems under stress (Odum 1985, Rapport et al. 1984).

The following sections about resident and anadromous fish present life history, habitat requirement information, and stock status information for selected fish species (Table B-1) that reside or migrate in southwestern Oregon within the range of the northern spotted owl and are considered species of interest or concern. Listed and candidate species under the ESA; species listed as endangered, threatened, sensitive, or priority by state governments; species of interest and species of concern to the AFS (Williams et al. 1989, Nehlsen et al. 1991, Higgins et al. 1992) are included in the following discussion. Specific information about some species and local populations is limited or unknown. In most cases, the preponderance of information describes the species of commercial or recreational interest in the region (i.e., salmon and trout species). Common and scientific names of fishes presented in this document are from Robins et al. (1991), except where noted in cases of AFS unrecognized species.

Resident Fish

Several resident fish species native to the Pacific Northwest occurring within the range of the northern spotted owl have been identified as "at risk" by the AFS (Williams et al. 1989, Nehlsen et al. 1991, Higgins et al. 1992) and state agencies (Weeks 1993 personal communication, Moyle et al. 1989). The following life history, habitat requirements, and stock status of these populations provide some information, but it is limited for some fish and local populations. Where possible, reasons for decline in population size are provided and current management actions are noted.

Lampreys (Family Petromyzontidae)

Lampreys (*Lampetra* spp.) are eel-like fish. They have no jaws or paired fins. Several species of lampreys occur in the Pacific Northwest, some are resident in fresh water and some are anadromous. All spawn in fresh water. Lampreys, like several other native fish, have social and cultural importance to the Indian peoples of the region (Scott and Crossman 1973).

Many lamprey species are parasitic, attaching to other fish. Some freshwater resident species are not parasitic. Generally lampreys live 2 to 7 years, most of this time spent as larval fish (ammocoetes) living in freshwater habitats such as streams, rivers, and lakes (Scott and Crossman 1973). The Pacific lamprey is discussed later in the anadromous fish section of this appendix.

Salmonids (Family Salmonidae)

Bull Trout

There are two native char (*Salvelinus* spp.) occurring within the range of the northern spotted owl. They are the bull trout (*S. confluentus*) and Dolly Varden (*S. malma*). Cavender (1978) described bull trout in 1978 and separation of the two species was accepted by the AFS in 1980 (Mongillo 1992). In western and southwestern Oregon, only the bull trout exists in isolated drainages. For discussion purposes, where appropriate, notes will be offered about Dolly Varden since they are very similar in habitat preference and lifehistory strategies (Rieman and McIntyre 1993, WDW 1993).

The bull trout occurs in Washington, Oregon, Idaho, Montana, and Nevada, as well as British Columbia and Alberta, Canada; overlapping the range of the northern spotted owl. Populations in the spotted owl's range occur in the Puget Sound and the coastal lowlands in western Washington; the Columbia River Basin in Oregon and Washington; and the Klamath River drainage, Klamath County, Oregon. The bull trout also occurred in the McCloud River in California but is considered to be extirpated (Rode 1990). The Dolly Varden is found only in Alaska, western Washington, and Canada (Mongillo 1992).

There are four forms of native char: anadromous, lake-dwelling, river-dwelling, and resident. Anadromous, lake-dwelling, and river-dwelling forms migrate to smaller tributary streams (second to fourth order) to spawn while resident populations tend to remain in the stream reach where they were hatched (Rieman and McIntyre 1993, WDW 1993). Shepard et al. (1984) found bull trout occurred most frequently in third and fourth order streams.

Bull trout and Dolly Varden have complex age structures, behavior, and maturation schedules (Rieman and McIntyre 1993). These complexities are important to the stability and persistence of populations and species. The diversity of traits and life history strategies is thought to stabilize populations in highly variable environments and help recolonize areas where segments of a population has been extirpated (Rieman and McIntyre 1993).

The majority of the following information is from Howell and Buchanan (1992), Meehan and Bjornn (1991), and Mongillo (1992).

Adult bull trout spawn in September and October (Shepard et al. 1984) and range in length from 14 to 36 inches (Lee et al. 1980). Adult anadromous Dolly Varden spawn as early as late August and as late as November (Meehan and Bjornn 1991) and range in length from 10 to 20 inches (Lee et al. 1980). Both species typically spawn in large, low-gradient cold streams over loose gravel and cobble having groundwater inflow (Brown 1992, Shepard et al. 1984), and near cover (Brown 1992). Sexual maturity is reached at 4 to 9 years (Shepard et al. 1984), females may deposit from 100 to 5 or 10,000 eggs, depending on the fishes size (Meehan and Bjornn 1991). Dolly Varden attain sexual maturity at 5 or 6 years of age (Meehan and Bjornn

1991). Bull trout and Dolly Varden survive spawning and may spawn in consecutive years (Shepard et al. 1984). Eggs are usually buried 4 to 8 inches in a redd (Shepard et al. 1984). Hatching is usually completed in January with emergence in April or May, the rate of development is dependent on water temperature (Meehan and Bjornn 1991, Pratt 1992). Fry begin feeding while in the gravel (Pratt 1992). Shepard et al. (1984) speculated that the choice to stay in the gravel may allow bull trout to be larger and more likely to survive after emergence. Emergence success appears to be affected by the proportion of sediment in the substrate (Pratt 1992). Water temperature seems to be an important factor in determining survival in the early life history of juvenile bull trout, with cool water temperatures resulting in higher egg survival and faster growth rates for fry and juveniles (Pratt 1992). McPhail and Murray (1979) found that egg survival varies with water temperature; water temperatures of 35° to 43°F provide 60 to 95 percent survival while temperatures 47° to 50°F provide 0 to 20 percent survival. There is also some evidence that water temperatures may dictate distribution of bull trout within a basin (Pratt 1992).

Unlike salmon and trout, fry and young-of-the-year bull trout are closely associated with the streambed and are often found on or in the substrate rather than in the water column (Meehan and Bjornn 1991). As the fish grow, they are found in the water column (Pratt 1992). Juvenile bull trout densities seem to be associated with the amount of fines in the substrate, with densities decreasing as the amount of fines increases (Enk 1985). They use pockets of slow water near high-velocity current zones. The structures that create the areas of slow water also provide cover and visual isolation (Pratt 1992). As juvenile bull trout grow they migrate to larger streams, rivers, or lakes. This migration can happen in the spring, summer, or fall. Woody debris, undercut streambanks, and clean cobble substrate seem to be important to providing cover for juvenile bull trout (Goetz 1991, Pratt 1984, McPhail and Murray 1979).

Structural diversity is a prime component of good bull trout rearing streams. Juvenile bull trout in southeastern Washington streams seem to prefer plunge and scour pools over other habitat types (Martin 1992). Deep pools containing large woody debris were found to contain the majority of overwintering salmonids in a southeastern Alaskan stream (Heifetz et al. 1986). In another study in southeastern Alaska, a decline in juvenile salmonid production was seen in two streams that were cleaned of woody debris. Yearling coho salmon and Dolly Varden (*Salvelinus malma*) were the fish species most affected by the loss of the overwintering habitat (Dolloff 1986). In a similar study in southeastern Alaska, Elliot (1986) found a loss of larger Dolly Varden and a decrease in the average size of fish in a small stream after removal of logging debris. Yearling bull trout and Dolly Varden are found in deeper and faster water than young-of-the-year fish (McPhail and Murray 1979). McPhail and Murray (1979) suggested that limitations in juvenile rearing habitat may the limiting factor affecting overall population levels of bull trout. Adult bull trout prefer deep pools of cold water rivers, lakes, and reservoirs (Moyle 1976).

Bull trout shorter than 4.5 inches feed on aquatic insects, while bull trout longer than 4.5 inches feed on fish and aquatic insects (Shepard et al. 1984). The diet of adult bull trout is mainly fish (Pratt 1992).

Bull trout are water temperature sensitive and are seldom found in streams with summer water temperatures more than 64°F. They are often found in areas near springs (Shepard et al. 1984). Water temperatures in the streams containing bull trout populations in the Wenatchee National Forest in Washington ranged from 39° to 63°F when monitored in 1989 and 1990 (WDW 1993).

The bull trout populations within the conterminous United States are a candidate species status under the ESA (USDI 1996). In 1994, the FWS conducted a formal status review to determine whether listing the bull trout as endangered or threatened under the ESA was warranted. The FWS found that listing the populations of bull trout within the conterminous United States is warranted, but precluded due to other priority listing actions; as a result, the status was elevated to a category 1 candidate (USDI 1994). In early 1996, the candidate list was revised and the bull trout was considered a candidate species under the revision. The Dolly Varden currently has no status under the ESA. The State of Oregon classifies bull trout as a game fish and has designated it as a sensitive-critical species (ODFW 1995). The AFS has classified the bull trout as a species of special concern due to modification and alteration of habitat and the introduction of predators and competitors (Williams et al. 1989).

Bull trout and Dolly Varden need undisturbed, clean, cold, and silt-free waters (WDW 1993). Channel stability, cover, temperature, substrate, and presence of migratory corridors appear to influence the abundance and distribution of bull trout (Rieman and McIntyre 1993). Several human actions have affected these habitat components (Bond 1992). These include habitat degradation from timber harvest, road construction, and agricultural practices. The habitat degradation includes riparian vegetation removal, water diversion or withdrawal, siltation, and sedimentation. In addition, introduction of nonnative species which prey on, compete with, and hybridize with bull trout; harvest; and eradication measures (bounties) have been responsible for declines in population levels and distribution of bull trout. In Washington, human activities such as timber harvest and road building are believed to be responsible for most of the habitat problems affecting these species (WDW 1993). These activities have caused excessive siltation and channel instability (WDW 1993). In Oregon, Ratliff and Howell (1992) found habitat degradation, passage barriers, mortality of downstream juveniles, overharvest, competition and hybridization with introduced species, and climate change are factors that have reduced or eliminated bull trout populations.

Goetz (1989) listed several factors affecting the survival of bull trout that are related to habitat quality. These include impacts of sedimentation on eggs and alevins while in the gravel and insufficient cover causing juveniles to move downstream where predation rates may be higher. Because they spawn in the fall, winter flood events that move gravel, eggs, and alevins can severely impact bull trout survival during the incubation period. Due to watershed manipulations such as timber harvest and road building, peak flow during these events may be increased thus increasing the possibility of gravel movement (Christner and Harr 1982).

Movement of individuals between populations allows for the flow of genetic material and supports local populations. Movement of individuals is also required to allow migration between wintering areas and summer feeding areas (Rieman and McIntyre 1993). Fragmentation of habitats, alteration of stream flow regimes and loss of instream habitat can affect the migration behavior and migration routes of bull trout. Rieman and McIntyre (1993) suggested that the persistence of a migratory life history strategy and the reestablishment or maintenance of stream migration corridors are crucial to the viability of bull trout populations.

In Oregon the basins within the range of the northern spotted owl with the highest-risk populations are the upper Deschutes River, Klamath County; the Hood River, Hood River County; the mid- and upper Willamette River, Lane and Douglas counties; and the upper Klamath River, Klamath and Jefferson counties (Ratliff and Howell 1992). Most of these bull trout populations occur on national forest lands.

Coastal Cutthroat trout

The coastal cutthroat trout (*Oncorhynchus clarki clarki*) is the most abundant cutthroat trout and has the broadest geographical range of any of the recognized cutthroat trout subspecies (Behnke 1992). It occurs along the Pacific coast of North America from Gore Point on the Kenai Peninsula, Alaska, to the Eel River Basin of northern California. It usually occurs inland to the crest of the Cascade Range in Washington and Oregon and to the crest of the Coast Range in British Columbia and Alaska, usually not more than 100 miles inland from the coast (Behnke 1992). The distribution pattern of the coastal cutthroat trout is similar to that of the coastal rain forest belt described by Waring and Franklin (1979).

Coastal cutthroat trout exhibit various life histories. There are both anadromous (sea-run) and resident (non-anadromous) populations. Within the resident types, local populations may be lake-dwelling and spawn in tributary streams, local populations may migrate into main river reaches to reside and return to tributary streams to spawn. The third resident type resides in small headwater streams, and may not move far from the reach where it hatched. Populations of these types occur throughout the range and may exist in the same river or stream system. Note that at the present time it is unknown whether these forms represent separate populations or are alternative life history strategies of one population, where they coexist. The contribution of freshwater migratory and nonmigratory coastal cutthroat trout individuals to the anadromous form is a point that has been discussed with little or no conclusion.

Anadromous coastal cutthroat trout show a wide range of life history patterns, which probably reflects adaptations to local conditions in a particular stream or river basin (Nickelson et al. 1992). Adult anadromous coastal cutthroat trout returning to spawn can be 18 inches long and weigh more than 6.5 pounds (Behnke 1992), size will vary by geographic area and age at return. Anadromous coastal cutthroat trout females usually mature as 4- and 5-year-old fish, entering rivers in summer and early fall (June through early October). Some fish may enter fresh water as late as March. Fish spawn from December through May in Washington, Oregon, and California. Peak spawning is in February. Spawning takes place in small first- and second-order streams (Nickelson et al. 1992), in riffles 6 to 18 inches deep in areas of gentle gradient. The substrate is clean, pea-sized gravel. Spawned-out anadromous coastal cutthroat trout return to the ocean within weeks of spawning, with seaward migration peaking in late March.

Incubation of anadromous coastal cutthroat trout eggs is 6 to 7 weeks followed by another couple of weeks for emergence from the gravel (Scott and Crossman 1973), usually in March through June. Newly emerged fry quickly move to and reside in low-velocity riffles, stream margin, and backwater and side-channel areas next to main-channel pools and riffles. As they grow, juveniles move into pool habitat. The selection of small streams by anadromous coastal cutthroat trout is seen as a strategy to help reduce interactions and competition with other salmonids such as steelhead and coho salmon (Nickelson et al. 1992, Johnston 1981). When competing with coho salmon fry, which occur in the same stream areas and are bigger and more aggressive, anadromous coastal cutthroat trout fry usually move into riffles. The interaction between these species is poorly understood.

By September anadromous coastal cutthroat trout average 2 to 3 inches in length and may move into larger streams or mainstem rivers. During the winter they move into pools seeking shelter around log jams, boulders, and undercut banks. They also may move back into the smaller streams to avoid winter freshets (Trotter 1989).

The freshwater residency of anadromous coastal cutthroat trout usually lasts 2 or 3 years but, depending on the locality, may range from 1 to 6 years (Trotter 1989). During this time the diet of anadromous coastal cutthroat trout is insects, salmon and sculpin eggs, and small fish. The peak migration of juvenile anadromous coastal cutthroat trout in Washington and Oregon is usually mid-May (Trotter 1989) but may last through mid-July. At the time of migration, fish are usually 8 to 10 inches long. Estuary and ocean distribution is limited to inshore and nearshore waters, usually within the influence of the natal stream or river (Wydoski and Whitney 1979). In estuarine areas fish usually reside in tidal areas or sloughs. In these areas, large woody debris may be an important habitat component (Nickelson et al. 1992). During this time anadromous coastal cutthroat trout feed on small baitfish and crustaceans (Behnke 1992). While in the ocean or marine environment, fish grow about 1 inch per month (Behnke 1992), and usually mature in their second year of ocean residence (as 4- or 5-year-old fish). They return to their natal stream to spawn. Most fish will return to freshwater areas to overwinter after their first summer of ocean residence. Estuary and ocean residency is discussed later in this appendix.

The lake- and river-dwelling freshwater migratory form of coastal cutthroat trout exhibits life history characteristics similar to the anadromous form, but instead of migrating to the ocean, these fish migrate to lakes or mainstem river reaches to grow and mature (Trotter 1989). Fish in some populations may be 30 inches long and weigh 17 pounds but the average is 12 inches long, weighing one pound (Scott and Crossman 1973). In river systems where anadromous and freshwater migratory forms occur, anadromous populations may spawn in lower sections of the stream than the freshwater migratory form (Trotter 1989).

Mature fish migrate into spawning streams during the fall and winter or spring. Spawning usually occurs from February through early June, depending on the area (Trotter 1989). Spawning areas for freshwater migratory coastal cutthroat trout may be upstream or downstream from feeding areas, and have similar characteristics to the anadromous populations' spawning areas (Trotter 1989).

After emerging from the gravel, freshwater migratory coastal cutthroat trout rear in the stream for 1 to 3 years before migrating to the mainstem river or lake (Trotter 1989). The diet of these fish is aquatic and terrestrial insects. As the fish grow, they may also feed on small fish such as sculpins (*Cottus* spp.) and stickleback (*Gasterosteus* spp.) (Trotter 1989).

The nonmigratory form of coastal cutthroat trout inhabiting the small headwater streams usually does not grow longer than 6 or 7 inches (Trotter 1989). These fish are shorter-lived than the migratory forms. Females usually mature as 2-year-old fish. Emergent fry are drift feeders, eating insects and residing in side channels and backwater areas close to the emergence area.

Resident populations of coastal cutthroat trout have been extensively studied in regard to effects of logging and removal of the forest canopy along streams (Behnke 1992). Information suggests that coastal cutthroat trout numbers may increase shortly after removal of the forest canopy near streams. This is due to an increase in the production of aquatic insects caused by increased sunlight entering the stream (Murphy et al. 1981) (see Appendix A). Increased productivity and increased trout numbers may be short-term effects, however, and in the longer term may be negated due to the elimination of cover and large woody debris that contribute to organic detritus, overwintering habitat, instream structure, and long-term habitat complexity.

In general, logging impacts seem to be changing the proportion of salmonid fish species and age composition (Reeves et al. 1993, Bisson et al. 1992). Timber harvest reduces the supply of

large woody debris and habitat complexity, increases sedimentation, and raises stream temperatures (Reeves et al. 1993, see Appendix A). Large woody debris is a source of pool habitats (Sedell et al. 1985). Its reduction in the stream, coupled with increased sediment, may increase riffles. This elimination of pools and large woody debris simplifies the stream habitat (Reeves et al. 1993). Riffles favor young coastal cutthroat trout and steelhead and disfavor older cutthroat trout and coho salmon, which prefer pool habitat.

Coastal cutthroat trout, because of their preference for heavy cover, appear to be more sensitive than other salmonids to streambed alterations and clear-cut logging (Reeves et al. 1993, Moring and Lantz 1975). Because migratory coastal cutthroat spend a greater part of their lives in the estuaries of coastal streams than do other salmonids, dredging and filling for agricultural, and urban and industrial development can have adverse effects on these populations (Giger 1972 a,b). In recent years populations of coastal cutthroat trout, especially the anadromous form, have declined (Nickelson et al. 1992, Palmisano et al. 1992, Trotter 1989). Reasons for this decline are land development, logging and road building, and agricultural practices that cause habitat loss and degradation (see Appendix A).

Rainbow Trout

Rainbow trout (*Oncorhynchus mykiss* spp.) are complex in physical characteristics and in life history patterns (Behnke 1992, Moyle 1976, Scott and Crossman 1973). The species is adaptable to the habitats and environments present throughout the western states. Behnke (1992) discussed three subspecies of *Oncorhynchus mykiss* that occur within the range of the northern spotted owl: the Columbia River redband trout in the Columbia River Basin east of the Cascade Range and in the upper Fraser River Basin of Canada (*O. m. gairdneri*), the McCloud River redband trout (*O. m. stonei*) in the upper Sacramento River Basin, and the coastal rainbow trout (*O. m. irideus*) whose range is west of the Cascade Range. The Columbia River redband trout and the coastal rainbow trout contain populations that are anadromous. The anadromous populations are known as steelhead.

Most rainbow trout are found in cool, high-gradient, fast-flowing streams and rivers. Moyle (1976) found that rainbow trout often occur with other salmonids, sculpins, dace, and suckers. Rainbow trout appear to be fairly successful at interacting with other fish species by being flexible in their behavior and habitat needs, being aggressive, and defending their feeding territories.

Rainbow trout mature as 2- or 3-year-old fish (Behnke 1992, Moyle 1976) and may live 7 years. Rainbow trout are spring spawners (February to June) although some high-elevation populations of rainbow trout may spawn in July and August due to water temperatures. Some populations of rainbow trout do spawn during the fall in rivers with unique water temperature characteristics, such as warm water springs (Behnke 1992). Fish taken from the McCloud River in June were sexually mature which suggests that they spawn in late spring (Moyle et al. 1989).

Rainbow trout eggs incubate for varying lengths of time, mainly determined by water temperature. Emergent fry take up residence in the small stream where they hatched and make use of stream edges for the first weeks, moving into pools and deeper water habitat as they grow. As juvenile rainbow trout grow they may move into mainstem rivers, lakes, or remain in the small streams where they were hatched (Behnke 1992).

Most steelhead mature and return their natal streams to spawn as 3- to 5-year-old fish (Nickelson et al. 1992) and may live to be 9 years old. Some stocks of steelhead return to the river of origin in April through July but do not spawn until February through April of the subsequent year. These steelhead are referred to as summer-run or summer steelhead because of their river entry timing (Bley and Moring 1988). In California, they are often referred to as spring-run steelhead (Moyle et al. 1989). These fish return from the ocean with immature gonads that mature during the next several months while the fish are holding in deep pools. During the summer migration they appear to eat infrequently (Barnhart 1986). Steelhead that return to rivers from November through March and spawn from January through May are referred to as winter-run or winter steelhead. These fish mature during their migration and spawn shortly after reaching the spawning areas (Nickelson et al. 1992).

Steelhead generally spawn in small, cool (45° to 58°F), moderate gradient (3 to 5 percent) streams during the spring (Nickelson et al. 1992). Fish ready to spawn generally seek a gravel riffle to deposit their eggs. Steelhead survive to spawn in subsequent years (Scott and Crossman 1973, Moyle 1976). The eggs usually incubate 3 to 4 weeks and fry emerge from the gravel 3 weeks after hatching. Emergent fry take up residence in stream margins with quiet water areas (Moyle 1976). As they grow, juvenile fish move into pools where they inhabit faster water velocity areas. Summer steelhead juveniles from the Rogue River Basin in Oregon move into the mainstem Rogue River shortly after emergence since many of these spawning and early rearing streams become dry during the summer (Nickelson et al. 1992). Juvenile steelhead spend 1 to 3 years in fresh water feeding on aquatic insects, crustaceans, aquatic worms, fish eggs, and occasionally small fish (Wydoski and Whitney 1979). Length at time of migration is 6 to 8 inches (Nickelson et al. 1992). Steelhead juveniles grow rapidly in the estuary and ocean environment and double their size (16 to 20 inches) by fall.

Some steelhead, known as "half-pounders," return to fresh water as immature fish, spend several months, and migrate back to the ocean without spawning. Half-pounder runs occur in the Rogue River in Oregon and the Eel and Klamath rivers in California (Nickelson et al. 1992). Steelhead spend a few months to 4 years in the ocean before returning to their natal stream (Nickelson et al. 1992).

Rainbow trout and steelhead are opportunistic feeders (Behnke 1992, Moyle 1976), usually feeding on aquatic and terrestrial insects. During the summer fish feed on drifting and bottom-occurring (benthic) organisms, while in the winter they eat only benthic organisms (Moyle et al. 1989). The size of the organism eaten depends on the size of the feeding fish, increasing as fish size increases (Moyle 1976). Steelhead continue to feed on insects as they migrate to the estuary and ocean, and as they grow, fish become a bigger component of their diet (Moyle 1976).

In many cases, usually in high-gradient streams, trout abundance is limited by habitat rather than food availability (Behnke 1992). In general, native trout populations require four kinds of habitat during the various life history stages: spawning, rearing, adult, and overwintering. Deficiencies in any of these habitats will limit population productivity (Behnke 1992). If spawning and rearing habitats are adequate, and the food availability would support a greater amount of trout biomass, then the available adult habitat would limit the population in most streams.

Minnows (Family Cyprinidae)

Oregon Chub

The Oregon chub (*Oregonichthys crameri*) is a small cyprinid, (1.5 to 2 inches long). This species was historically recorded only in the Willamette River drainage in Oregon and was widely distributed throughout the lowland areas of the Willamette Valley. It is primarily restricted to an 18-mile stretch of the Middle Fork of the Willamette River, just 2 percent of its historic range (USDI 1994). The Oregon chub is found in backwater areas and creeks principally in the vicinity of Dexter Reservoir and Lookout Point Reservoir on the Middle Fork of the Willamette River, the William Finley National Wildlife Refuge, in the North Santiam River, and in some other small tributaries to the Willamette River (Weeks 1993 personal communication).

Historic habitats of the Oregon chub were mainstem meanders, oxbows, backwater sloughs, marshes, and beaver ponds. The habitats used now generally have a substrate of silt, gradually sloping banks, varied aquatic vegetation with overhanging riparian vegetation and other hiding cover, little or no water velocity, depth mostly less than 6 feet, and summer water temperatures exceeding 64°F (Markle et al 1991). Many of the meanders, oxbows, sloughs, and side channels have been eliminated by channelization, diking, draining, and filling. Large reservoirs constructed for flood control have changed downstream patterns of flooding, streamflow, and temperature. Various sources of pollution have reduced water quality. These activities typically have the greatest cumulative effects on low-gradient and low-elevation waterways well suited to the Oregon chub. The decline may also be related to predation and competition by introduced fish species that frequent the same habitats as the Oregon chub (Markle et al. 1991).

Oregon chub spawn in aquatic vegetation in still water from May to August (Pearsons 1989). The spawning areas also provide juvenile rearing habitat. Spawning males are more than one inch long. Spawning males longer than 1.3 inches establish territories for courtship (Markle et al. 1991). The Oregon chub is an opportunistic feeder with a diet of invertebrates (Markle et al. 1991).

The Oregon chub was listed as an endangered species by the FWS under the ESA on October 18, 1993 (effective November 17, 1993). The basis for the listing was diminished backwater habitat due to flood control activities that reduced or eliminated much of the Willamette River's braided channel pattern and impacts of predation and competition from nonnative species (USDI 1994). The species is considered sensitive-critical by the State of Oregon (ODFW 1995). If a species is listed as endangered or threatened under the Oregon Endangered Species Act, a program addressing the protection and conservation of the species must be adopted.

A conservation agreement for the Oregon chub in the Willamette Valley became final in January 1992. The agreement is between the FWS, and the Oregon Department of Fish and Wildlife (ODFW), U.S. Army Corps of Engineers, U.S. Forest Service, U.S. Bureau of Land Management, and Oregon Department of Parks and Recreation. The stated objectives of the agreement include implementation of actions to protect and improve habitats used by the Oregon chub, establishment of additional populations in suitable habitat, and public education and involvement (ODFW 1992). The objectives of this interagency agreement are the same as Oregon chub management objectives for several Willamette Valley subbasin fish management

plans. These objectives will be the core of a proposed conservation program when the species is considered for listing as endangered or threatened under the Oregon Endangered Species Act by the Oregon Fish and Wildlife Commission.

Umpqua Chub

The Umpqua chub (*Oregonichthys kalawatseti*) is a small cyprinid, (1.5 to 2 inches long). It occurs in the Umpqua River drainage in southwestern Oregon. Until recently this species was included as part of the Oregon chub (Robins et al. 1991), but now is considered a separate species (Markle et al. 1991).

The habitats used by the Umpqua chub are characterized by reduced flow, substrates of bedrock or silt, and daytime temperatures in the range of 63°to 76°F. These areas also have aquatic vegetation and riparian vegetation made up of grasses and/or trees and shrubs (Markle et al. 1991).

The Umpqua chub's diet consists of invertebrates, but the species seems to feed nearer the bottom than the Oregon chub (Markle et al. 1991). The Umpqua chub spawns over rocky substrate whereas the Oregon chub spawns in aquatic vegetation (Markle et al. 1991). This trait along with the preference for higher velocity current are the major differences between the Umpqua chub and the Oregon chub (Markle et al. 1991).

This species is designated as a sensitive-vulnerable species by the State of Oregon (ODFW 1995). It is considered vulnerable due to competition and predation by nonnative fish species, such as bass, and by other fish species of concern in the basin such as coastal cutthroat trout and coho salmon .

Suckers (Family Catostomidae)

Jenny Creek Sucker

Jenny Creek, located in Jackson County, Oregon, and Siskiyou County, California, is a tributary of the Klamath River that drains the eastern slope of the divide between the Rogue River and the Upper Klamath Lake drainage (Currens 1990). Isolation of the fish life in Jenny Creek by a series of three, 30-foot, 5-million-year-old waterfalls may have allowed genetic differences to evolve between these species and those of adjacent basins (Hohler 1981, Currens 1990, Harris and Currens 1993). Investigations into species description, genetic composition, and life history of the Jenny Creek sucker (*Catostomus rimiculus* spp.) and a possible population of redband trout (*Oncorhynchus mykiss* spp.) are being conducted.

The Jenny Creek sucker population has been described as a dwarf form of the Klamath smallscale sucker (*C. rimiculus*) that occurs in the Klamath and Rogue river basins (Hohler 1981). The average size of a 3- or 4-year-old Jenny Creek sucker is 6 to 8 inches, based on field work conducted by Hohler (1981). Jenny Creek suckers are opportunistic feeders found in low water-velocity habitats that have good water quality. During sampling in 1979 Hohler (1981) found fish in Jenny, Beaver, Corral, Keene, and Johnson creeks. Sampling throughout the year Hohler (1981) documented a migration upstream to spawn in the spring and a migration downstream in the fall.

The Jenny Creek sucker is designated as a sensitive-peripheral or naturally rare species by the State of Oregon (ODFW 1995). The AFS considers the Jenny Creek sucker a species of concern because of habitat elimination and degradation, and competition from introduced species (Williams et al. 1989). The species is vulnerable to activities that affect habitat and water quality such as irrigation withdrawals, grazing, and forest practices (Weeks 1993 personal communication). The 1993 stock status review by the ODFW reported that the population appears stable and habitat conditions are improving (Weeks 1993 personal communication).

Lost River Sucker and Shortnose Sucker

The Lost River sucker (*Deltistes luxatus*) is native to the upper Klamath River drainage of Oregon and California including Upper Klamath Lake, and its tributaries; the Lost River system including Clear Lake; and Tule, Lower Klamath and Sheepy lakes (Williams et al. 1985, Stine 1982, Moyle 1976, Andreason 1975). The shortnose sucker (*Chasmistes brevirostris*) has a similar distribution except for an apparent wider distribution in the Lost River system. Historically, both species provided cultural, social, and economic value to the Indians and early immigrants to the area. They were used as a source of food by the Klamath and Modoc Tribes, and by the early settlers and their livestock.

Lost River suckers are characterized as long-lived, large individuals (adults can be 39 inches long and more than 40 years old) that reside in the lakes of the area and move into streams and rivers as early as February but usually in late March or early April to spawn. Shortnose suckers can be 19 inches long and live more than 30 years. Shortnose suckers have spawning habits similar to Lost River suckers. Spawning activity usually lasts well into May, after spawning adults return to the lakes. Based on sampling conducted in Upper Klamath Lake, suckers become sexually mature between the ages of 6 to 14 years, with most maturing at age 9. Shortnose suckers mature at an earlier age (5 to 8 years) (Buettner and Scoppettone 1990). There is evidence that a distinct population of Lost River suckers spawns near Sucker Springs in Upper Klamath Lake, and there may have been several other distinct populations at other lakeshore springs. Populations of shortnose suckers also spawn in several spring areas in Upper Klamath Lake (Klamath Tribe 1991). Spawning takes place where gravel is available.

Fry usually migrate from the streams and rivers to the lakes shortly after they can swim (May and June). While migrating, fry seem to move during the evening hours (Coleman and McGie 1988). During the day migrants are found in shallow water shoreline areas. Research into habitat preference is being conducted (USDI 1993).

Adult fish spend the late summer and early fall months in the northern areas of Upper Klamath Lake. This seems to be related to poor water quality conditions in the rest of the lake (Coleman and McGie 1988). There is documentation of large concentrations of fish in the Sprague River during August 1966 and 1967 that seem to have been caused by poor water quality conditions in Upper Klamath Lake.

In July 1988 the FWS listed the Lost River sucker and the shortnose sucker as endangered species under the ESA. They were listed as endangered species by the State of Oregon in November 1991. The State of California had designated the Lost River sucker and the shortnose sucker as rare in June 1971 and listed the species as endangered in January 1974. Information is somewhat limited about the habitat requirements of these species for all life stages, most of the data pertains to habitat utilization. For more detailed information, refer to

the Lost River Sucker and Shortnose Sucker Recovery Plan (USDI 1993) and the several references cited in that document.

Reasons for the decline and subsequent listings of the Lost River sucker and shortnose sucker as endangered include: damming of the rivers and associated water diversions, dredging and draining of marsh areas, fragmentation of habitat, predation and competition by introduced species, overfishing, and poor water quality of the lakes and streams related to timber harvest, livestock grazing, agriculture practices, chemical contamination, and removal of riparian vegetation. The FWS considers reduction and degradation of lake and stream habitats in the upper Klamath River Basin as the most important factor in the decline of the species (USDI 1993).

In 1970 the Oregon State Water Resources Board noted that logging and road building cause erosion and sedimentation and that these practices did not provide soil stability (USDI 1993). To compound the habitat degradation, the eroded soils carried salts and nutrients that added to the eutrophication of Upper Klamath Lake. The 1987 amendment to the Oregon Forest Practices Act has led to some improvement compared to past practices regarding riparian protection (USDI 1993).

Sculpins (Family Cottidae)

There is one species of sculpin that is of special concern in southwestern Oregon, the slender sculpin (*C. tenuis*) (Williams et al. 1989).
Sculpins are species of special concern due to water quality degradation caused by agricultural runoff and watershed alteration, and flow alteration and isolation of populations caused by dams. In general, there is a lack of information about the specific species of sculpins (Moyle et al. 1989, Lee et al. 1980). Because of this lack of data, the ability to make wise management decisions regarding these species is a concern (Moyle et al. 1989).

Slender Sculpin

The slender sculpin is 2 to 2.8 inches long. It occurs in the Upper Klamath and Agency lakes and their tributaries and in the Klamath Irrigation Canal of Oregon (Lee et al. 1980). Little is known about the life history and habitat requirements of the slender sculpin (Lee et al. 1980). It is thought to inhabit still and slow-flowing water areas, but has been found in swifter-flowing water, and seems to be associated with a wide variety of substrates.

The AFS considers the slender sculpin a species of concern because of habitat elimination and degradation, and competition from introduced species (Williams et al. 1989).

Anadromous Fish

Anadromous fish native to the Pacific Northwest include several species of lamprey, sturgeon (*Acipenser* spp.), and salmonids. One species of anadromous lamprey and several stocks of anadromous salmonids have been identified by various articles or agencies as species of concern or species "at risk" of extinction (Williams et al. 1989, Nehlsen et al. 1991). The following species descriptions are meant to provide some understanding of the life history and habitat requirements of anadromous fish of the region.

Lampreys (Family Petromyzontidae)

Pacific Lamprey

The Pacific lamprey (introduced in the resident fish section of this appendix) occurs in several of the river basins in Washington, Oregon, and northern California. The only long-term data available are from fish counts at Winchester Dam on the North Umpqua River in Oregon. This data set indicates a marked decrease in the lamprey population in the last several decades (Weeks 1993 personal communication). The likely causes of decline are habitat degradation and destruction of spawning and rearing areas. Moyle and Yoshiyama (1994) also mentioned that Pacific lamprey populations in southern California coastal areas may be declining.

Pacific lamprey range in length from 12 to 27 inches (Moyle 1976). They generally return to rivers and streams from July through September (Scott and Crossman 1973). Pacific lamprey are not sexually mature when they enter fresh water and usually spend the winter months hidden under rocks and logs waiting to mature.

Spawning takes place from April through July in cool headwater streams, similar to the habitat needed by salmonids. Redds are dug in sandy gravel near the top of a riffle by the male and female fish. Eggs are adhesive and cling to the rocks after being deposited by the female. Females are capable of producing several thousand eggs (34,000 to 106,000 estimated for a 16-inch fish) (Scott and Crossman 1973). Eggs hatch in 2 to 3 weeks. After emerging from the redd, the ammocoetes burrow into the mud substrate downstream of the redd. This life stage can last 4 or 5 years. During this time the ammocoetes are able move to other areas and have been picked up in samples during all times of year (Moyle 1976). Ammocoetes are filter feeders, filtering microscopic organisms from the passing water. They are usually 4 inches long after their first year of life. When they become adults, individuals are 5 to 12 inches long and are ready to migrate to the ocean or estuary. After spending a year to 20 months in the ocean, lamprey return to fresh water to spawn.

There are landlocked populations of Pacific lamprey that migrate into lakes to grow and mature. These populations are parasitic on the resident fish of the lake. After residing in the lake they migrate up the tributary streams to spawn (Scott and Crossman 1973).

It is considered a sensitive-vulnerable species by the state of Oregon based on widespread declines in abundance (ODFW 1995).

Salmonids

Several species of native anadromous salmonids occur in southwestern Oregon within the range of the northern spotted owl. These include two species of Pacific salmon (1) chinook (*Oncorhynchus tshawytscha*), and (2) coho (*O. kisutch*); and two forms of trout (1) steelhead and (2) anadromous coastal cutthroat trout. The general life histories of anadromous forms of trout were described in the resident fish section of this chapter.

Chinook salmon historically occurred in the Pacific Ocean, the Arctic Ocean (rarely), Bering and Okhotsk seas, Sea of Japan, and the river systems flowing into these bodies of water (Groot and Margolis 1991, Scott and Crossman 1973). In North America they occurred from Point Hope, Alaska, south to the Ventura River, California.

Coho salmon occurred historically in the Pacific Ocean and the river systems flowing into it from Monterrey Bay, California, west to Hokkaido, Japan (Groot and Margolis 1991, Scott and Crossman 1973). In North America they occurred from Point Hope, Alaska, south to Monterey Bay, California.

The current distribution of some of these species has changed from the historical distribution. Some of the changes in range were caused by translocation of fish to areas such as the Great Lakes area of the United States and New Zealand (Scott and Crossman 1973). These translocations were often a response to enhance fishing opportunities or replace fish species that had declined or been extirpated. Extirpation of stocks in their historical range occurred through loss of habitat or blockage of access to spawning and rearing areas, overfishing, and introduction of exotic species and have been well documented in recent documents (Nehlsen et al. 1991, Higgins et al. 1992, Frissell 1993). Populations of all of the anadromous salmonids occurring in the range of the spotted owl are in the southern edge of their original distribution, which may make them more susceptible to climate change, habitat loss, and other disturbances.

Anadromous salmonids spawn in fresh water in redds in rivers, and in tributary streams and lakes. Pacific salmon die shortly after spawning, while steelhead and anadromous coastal cutthroat trout do not. After rearing in fresh water from a few days up to 3 years, they migrate to the ocean where they spend 1 to 5 years feeding (Groot and Margolis 1991). The early marine environment residency usually is within bays, estuaries, and nearshore areas. Substantial growth in this environment is critical to the survival of ocean-bound juvenile migrants (Table B-2) (Pearcy 1992).

Anadromous salmonids have a strong tendency to return to their river of origin. As fish migrate upstream, they are separated into groups of individuals that are isolated from other groups as they enter the spawning streams. These local groups or populations must be able to adapt to the characteristics of the stream and associated watershed in order to survive. Stream and watershed characteristics differ between watersheds due to factors such as geology, precipitation, climate, and topography (see Appendix A). This results in a collection of local populations that uses a wide variety of freshwater habitats. This adaption has resulted in the development of a wide range of life history characteristics and many reproductively isolated populations or stocks (Ricker 1972). This wide range of life history characteristics may be important to the stability and persistence of populations and species. A diversity of traits is thought to stabilize populations in highly variable environments and help recolonize areas where segments of the population have become extirpated (Rieman and McIntyre 1993).

The native stocks of anadromous salmonids in the western United States evolved during thousands of years in the natural system of a specific river basin or watershed. These stocks are adapted to unique local habitat regimes and characteristics (Mayr 1971). The adaptation of a stock to the environment provides a set of characteristics that allows the stock to improve fitness in that particular environment (Mayr 1971). Different juvenile life history strategies have also evolved to meet the habitat and environment particular to the specific river basin or watershed (Reimers 1971). Rich (1920) observed juvenile chinook salmon in the Columbia River estuary throughout the year, suggesting that a wide variety of migration traits and life history strategies existed. It is common to find several salmonid species and stocks existing in the same stream or river reach in the Pacific Northwest. Each of these stocks has different habitat needs. General habitat needs are well documented (Bjornn and Reiser 1991, Groot and Margolis 1991, Scott and Crossman 1973). This type of fish community complexity needs an

aquatic system that provides diverse but complementary regimes to accommodate the requirements of a particular species or stock (Randall et al. 1987).

The rearing habitat and migration habitat in several of the river basins have changed dramatically due to land use impacts (timber harvest, agriculture, urbanization, and road construction) and development of waterways (dam construction, dredging, channelizing, and streambank stabilization). These changes include loss of habitat complexity, increases in frequency of riffle habitats, loss of pool habitats, and degradation of water quality. Changes in the freshwater habitat, in combination with other factors such as overfishing and introduction of nonnative fish species or introduction of hatchery-reared fish, have led to the extinction of some stocks (Williams et al. 1989, Moyle and Williams 1990, Nehlsen et al. 1991) and the listing of Snake River sockeye salmon as endangered, Snake River spring/summer and fall chinook salmon as endangered, and the Sacramento River winter chinook salmon as endangered under the ESA. The National Marine Fisheries Service (NMFS) has proposed to list the coho salmon throughout is range in Washington, Oregon, Idaho, and California as threatened or endangered species under the ESA. Additionally, coastal cutthroat trout in the Umpqua River basin of Oregon was recently and the Klamath Mountain Province steelhead in southern Oregon and northern California were proposed by NMFS for listing as endangered under the ESA.

The basic spawning, rearing, migration, and ocean distribution mechanisms, needs, and other biological requirements of salmon and steelhead have remained unchanged over time.

Adult Migration and Spawning

The timing of many runs of anadromous salmonids corresponds with peak river flow (Collins 1892; Pritchard 1936; Cramer and Hammack 1952; Andrew and Geen 1960; reviews in Major and Mighell 1966, Banks 1969, Baker 1978). Coho salmon returning to Oregon coastal rivers, congregate in bays and estuaries, entering the rivers after fall storms have increased river discharge (Nickelson et al. 1992). High flows probably provide favorable migrating conditions for adult salmonids.

Salmon usually cease feeding after entering fresh water and depend on their energy stores for migration, gonadal development, and spawning. Adult salmon exhaust virtually all energy reserves prior to spawning and death (Idler and Clemens 1959, Gilhousen 1980). Extreme flows (both high and low) and high water temperatures can cause delays in the spawning migrations of some salmonid stocks in the Columbia, Snake, and other rivers (Thompson 1945, Fish and Hanovan 1948, Cramer and Hammack 1952, Major and Mighell 1966, ODFW 1977, Johnson et al. 1982, Liscom et al. 1985, Shew et al. 1985). High water temperatures, in addition to blocking migration, can increase the rate at which limited energy is consumed for standard metabolism (Fry 1971). Females are more susceptible to delays in migration (Godfrey et al. 1954), perhaps because they have less surplus energy than males (Gilhousen 1980). There are also differences among runs, and between early and late components of runs, with respect to energy reserves and swimming ability (Gauley 1960, Gauley and Thompson 1963, Gilhousen 1980). Delays caused by an unfavorable migratory environment can contribute to reproductive failure of salmonids.

Salmon stocks have evolved discrete populations that return to particular areas which allow them to effectively use a wide variety of habitats. Different temperature regimes that regulate maturation, incubation, and fry emergence have a major effect on run timing. As water temperatures decrease from upstream to downstream reaches in the fall, time windows for egg deposition in specific sites determine the spawning sequence. For example, mid-Columbia River spring chinook spawn in cooler headwater tributaries from July to mid-September, while summer chinook spawn in warmer downstream areas during October, and fall chinook spawn in the mainstem during late October and November (Meekin 1963).

Chinook salmon return to fresh water to spawn as 2-year-old to 6-year-old fish, but may be 8 or 9 years of age and can enter river systems from late February to December (Scott and Crossman 1973). Adult chinook salmon usually range in length from 29 to 32 inches (Lee et al. 1980). Based on this run timing, most chinook salmon are usually divided into three different runs: spring, summer, and fall. Spring chinook salmon generally enter rivers during March, April, and May. Summer chinook salmon begin their upstream migration during late May, June, and July. Fall chinook salmon enter rivers beginning in late July and August and may return as late as December in some rivers. The three runs can occur in the same river basin.

Spring chinook salmon have a unique life history pattern that includes entering fresh water while their gonads are immature, then maturing during their summer holding period (Marcotte 1984). For spring chinook adults, fish holding in an area seems to depend on the size (volume) and depth of the pools, amount of cover, and proximity to patches of gravel suitable for spawning (Moyle et al. 1989). The pools are at least 3.3 to 10 feet deep with bedrock bottoms and moderate water velocities (Marcotte 1984). They usually have a large bubble curtain caused by upstream turbulence at the head, underwater rocky ledges, and shade cover throughout the day. Spring chinook also seek cover in smaller "pocket" water behind large

rocks in fast water. Habitat preference curves determined by the FWS for adult chinook in the Trinity River, California, indicate that pool use declines when depths are less than 7 feet (Marcotte 1984). Barnhart and Hillemeier (1993) assessed summer holding habitat for adult spring chinook in the South Fork Trinity River, California. They found pool length, width, volume, area, percent boulder cover and whether the pool had a cold water area to be significantly correlated with presence of spring chinook. Barnhart and Hillemeier (1993) also found indications that once a holding area is selected fish did not leave and there was little movement of fish between pools from mid-July through mid-September. During this holding period spring chinook do not feed and rely on body fat for energy to maintain body functions and allow maturity of gonadal material.

Spring chinook salmon enter coastal Oregon streams and rivers from March through May and migrate to areas near spawning grounds where they hold for 3 to 4 months (Nicholas and Hankin 1988). Most spawning migrations are 25 to 60 miles, except in the Umpqua and the Rogue river basins where spring chinook migrate more than 125 miles. Because of this, Nehlsen (1994) considered these stocks regionally unique. These fish generally spawn in September and October.

Coho salmon return to fresh water to spawn generally as 3-year-old fish but can also return as 4-year-old fish. Adult coho salmon usually range in length from 18 to 24 inches (Lee et al. 1980). A percentage of the spawning population may also be 2-year-old "jack" coho salmon. Coho salmon usually return to their natal stream during the fall, the migrations may be triggered by fall rains which increase the river flows. They spawn from October to late December or early January but may spawn as late as March or early April (Sandercock 1991, Cramer and Cramer 1994). Coho salmon prefer to spawn in low-gradient (less than 3 percent), cool, tributary streams in areas of clean pea-sized gravel.

Coho salmon spawn in coastal Oregon systems in November, December, and January (Cooney and Jacobs 1992). Based on spawning grounds survey information, peak spawning times can vary, but seem to occur in late November or December in most coastal streams. In most cases coho salmon do not enter small tributaries until a heavy rain has increased the streamflow.

Steelhead have a strong migratory nature and will fight their way past stream barriers that typically stop chinook salmon. Steelhead typically spawn farther up in a river system, and in smaller streams than those used by chinook salmon.

Water velocity is an important factor in redd site selection and construction for all Pacific salmon (Chambers 1956, 1960; Meekin 1967a; McCart 1969), and as a result salmon often locate their nests at the head of a riffle in the tailout of a pool. Water flow is necessary to prevent dewatering of redds and to keep redds clean of sediment and well aerated. A shortage of oxygen caused by the lack of adequate flow through the gravel beds jeopardizes egg and larvae survival (Royce 1959). The most important factor in egg and larvae survival is the quality of the water circulating in the spawning gravel (Chambers 1956). This flowing water must circulate adequate oxygen, be a suitable water temperature, and lack any deleterious chemicals.

Pacific salmon have a small number of eggs (fecundity) and a large egg size relative to fish size (Groot and Margolis 1991). Fecundity is also considered small because Pacific salmon die after spawning. The fecundity of Pacific salmon generally increases with length and weight of

the fish. Average fecundity also varies between stocks of the same species and between years for the same stock (Rounsefell 1957). Several factors appear to affect the fecundity of females within a population including size of the female and number of years spent in the ocean (Rounsefell 1957, Groot and Margolis 1991). The length of time spent in fresh water as juveniles does not seem to be a factor in determining fecundity (Groot and Margolis 1991). Environmental factors in the ocean that affect growth and maturation of individual fish also may determine fecundity.
Eggs size is an important factor in determining size of alevins and emergent fry (Groot and Margolis 1991, Behnke 1992). This subsequently plays a factor in the growth and survival of the fish (Groot and Margolis 1991), with larger fry having increased chances of survival. Egg size varies by species with chinook salmon having the largest eggs and sockeye salmon having the smallest eggs (Groot and Margolis 1991). Egg size of Oregon coastal chinook salmon increased with fish size (Nickolas and Hankin 1988).

Fecundity and egg size are factors in determining productivity of a given stock of fish. Given that fish have to sacrifice egg number for egg size or vice-versa, the value of different aged and sized fish making up the spawning population may allow fish populations to address variable environmental factors such as ocean conditions and freshwater rearing conditions (Groot and Margolis 1991).

The depth of eggs in the substrate is an important factor for proper emergent timing and survival. Survival usually increases with depth. The depth needed for optimum emergent fry survival varies by species, age, egg size, substrate, and water quality conditions. Chum salmon, for example, need at least 12 inches of gravel over the eggs to prevent excessive premature emergence, and 16 inches for optimal emergence and survival (Bruya 1981 cited in Salo 1991). This can be affected by the quality of the substrate (such as sediment buildup) and intergravel conditions (such as water flow and dissolved oxygen) (Meehan 1991).

Seasonally high flows can play an important role in flushing harmful fine material from spawning gravel (Reiser et al. 1985). The amount of water circulating through the gravel increases with the seasonal increase of water flow during spring runoff. The lack of seasonally high flows has led to a compaction of gravel in some areas and an accumulation of fine material in the gravel (Chapman et al. 1986). Silting is one cause of low survival in salmonid eggs and larvae (Shapovalov and Taft 1954), and consequently the lack of flow (and subsequent siltation process) hinders salmonid spawning success. Gravel can become sedimented except where spawning is concentrated each year. The tendency of spawners to concentrate in high-use spawning areas in the Hanford Reach of the Columbia River (Dauble and Watson 1990) may reflect the high relative suitability of gravel that has been cleansed of fines by redd construction in prior years. High flows during spawning can provide a greater area for spawning when space is limiting, but of equal or greater importance is the maintenance, until fry have emerged, of flow levels close to those that prevailed during spawning (Thompson 1974, Graham et al. 1980, Chapman et al. 1986).

Emergence and Rearing

After emerging from the redd, juvenile salmon, depending on the species, spend from a few days to 3 years feeding in fresh water before migrating to the marine environment (Table B-2).

The timing of hatching and fry emergence of salmon and steelhead varies among the different stocks because of different environmental conditions and perhaps genetic differences. After

hatching, salmon alevins remain in the gravel interstices for an extended period. Alevins are negatively phototactic (light sensitive) which encourages further submergence in the gravel and prevents premature emergence (Godin 1982). As the yolk sac is absorbed alevins develop positive rheotactic (current sensitive) and phototactic responses and begin an upward migration in the gravel (Dill 1969).

Salmon fry are about 1 to 1.5 inches long when they emerge from the gravel. Emergence is primarily at night, and the fry disperse into a wide variety of freshwater habitats. The different species select different rearing habitats which reduces competition for space and food. Flow, water velocity, and water depth determine the amount of suitable habitat available for rearing fish. The amount, type, and location of cover is important during rearing in streams because cover provides food, shade, temperature stability, protection from predators, and overwintering habitat. Substrate composition is also important for rearing because the highest production of invertebrates is in habitats with gravel- and rubble-sized materials and production decreases as the size of the substrate particles decreases (Bjornn and Reiser 1991).

Movement of fry downstream immediately after emergence is typical of most chinook populations (Bjornn 1971, Reimers 1971, Healey 1980, Kjelson et al. 1982). Movement of chinook fry occurs mainly at night (Reimers 1971, Lister et al. 1971, Mains and Smith 1964). River discharge plays a role in stimulating movement of chinook fry downstream (Kjelson et al. 1981, Healey 1980) and may be a key dispersal mechanism. Other factors such as inter- and intra-specific competition may also play a role in dispersal.

Chinook salmon fry in streams change habitats as they grow older. After an initial hiding period associated with bank cover and shorelines, they move progressively into deeper, high water-velocity areas, and rockier habitats (Lister and Genoe 1970, Everest and Chapman 1972). Spring chinook juveniles hide under large rocks and debris during overwintering (Chapman and Bjornn 1969).

After emergence from the gravel, coho salmon fry initially congregate in schools in areas with cover such as side channels (Sandercock 1991). As they become older, coho salmon juveniles set up territories in both pool and riffle areas and are best adapted to holding in pools (Hartman 1965). Their abundance in streams is limited by the number of suitable territories available (Larkin 1977) and they are generally displaced downstream if they are unable to defend a territory.

Juvenile steelhead tend to occupy the shallow riffle areas, particularly during the first year of life (Hartman 1965) and are more closely associated with the bottom of streams than are coho or chinook salmon (Hartman 1965, Edmundson et al. 1968). The highest densities of juvenile steelhead occur in areas containing instream cover (Johnson 1985). They may migrate to lower stream reaches to avoid freezing conditions in upper tributaries (Howell et al. 1985). Most summer steelhead rear in fresh water for 2 years and some for 3 years before migrating to the ocean (CBFWA 1991).

The primary diet of juvenile salmon in rivers is larval and adult insects of both terrestrial and stream origin. The diet of chinook rearing in fresh water is composed primarily of larval and adult insects. Crustacean zooplankton, primarily Cladocera, are important in the diet of chinook in the lower Columbia River in July and August but insects are the predominate food during the rest of the year (Craddock et al. 1976). Coho primarily feed on drifting terrestrial and stream insects (Mundie 1969).

Juvenile Migration

Migratory behavior is controlled by genetic and environmental factors (Randall et al. 1987). As early as the 1920s the migration patterns of juvenile chinook salmon were considered to be inherited by subsequent generations in the Columbia River (Rich and Holmes 1929). In a review, Randall et al. (1987) pointed out that the genetic influences on the age of smolting within species have been underestimated in the past. Recent findings indicate that chinook salmon in the Nanaimo River, British Columbia, which are characterized by a specific age and size at seaward migration, are seemingly a genetically distinct sub-population (Carl and Healey 1984). At the turn of the century apparently a wide variety of migratory traits existed. Rich (1920) observed juvenile chinook salmon in the Columbia River estuary throughout the year. Current knowledge suggests that a wide variety of migration patterns among stocks has a genetic basis.

The onset of migration is closely associated with the smoltification process in juvenile salmonids. Smoltification includes changes in body shape, appearance, and function, resulting in migratory behavior and the ability to live in salt water (Bern 1978, Folmar and Dickhoff 1980). Numerous body shape changes such as the weight-to-length ratio, coloration, change in fin shape and coloration, and development of teeth result in a smolt profoundly changed from the freshwater juvenile (Vanstone and Market 1968, Gorbman et al. 1982, Winans and Nishioka 1987). Many body function changes are related to each of these general changes and together typify smoltification (Folmar and Dickhoff 1980, Wedemeyer et al. 1980, Hoar 1988). Behavioral changes associated with smoltification include restlessness, onset of schooling behavior, and becoming more of an open water organism (Hoar 1965, McKeown 1984). The cumulative effect of these changes is that smolts are no longer adapted to remain in freshwater habitats, but are well-adapted for saltwater entry.

Juvenile salmonids migrate from their freshwater habitats to the marine environment by active swimming, passive transport by the current, or both. In considering these modes Thorpe et al. (1981) stated "It would be energetically inefficient and ecologically imprudent for smolts to swim actively downstream when a river could transport them passively over the same route. Pressure to evolve such active behavior would only arise if the passive transport system was too slow, or resulted in the delivery of smolts into the sea at an inappropriate season." Smith (1982) postulated that smolts actively swim upstream, but because of their reduced swimming performance are swept downstream. In fact, the only active migration of smolts that occurs routinely appears to be associated with sockeye migration through lakes (Johnson and Groot 1963, Groot 1965) and the movement of fish out of backwaters.

Early observations of chinook salmon support the hypothesis of a mostly passive migration. In a study conducted on the Sacramento River in California from 1896 to 1901, Rutter (1904) stated "there is no doubt that in migrating the fry drift downstream tail first, keeping the head upstream for ease in breathing as well as for convenience in catching food floating in the water" (his reference to fry is somewhat misleading in that the fish were about 2 inches long). The hypothesis of passive migration is also supported by numerous observations of Atlantic salmon (*Salmo salar*) (Thorpe and Morgan 1978, Tyler et al. 1978, Thorpe et al. 1981, Fried et al. 1978).

Spring freshets allow smolts to quickly move through the streams and rivers with a minimum of energy expended and with protection from predation afforded by the high volume of runoff, high river velocities, and high turbidity. The physiological, morphological, and behavioral changes

that occur during the smoltification process before and during migration evolved under these conditions when seasonal increase in runoff provided rapid migration (CBFWA 1991).

Several authors have suggested that well-developed estuaries and bays are important in the growth and survival of anadromous fish (Dadswell et al. 1987), especially juvenile anadromous salmonids in the first few months after leaving the freshwater environment (Groot and Margolis 1991, Bottom et al. 1986). These areas may be able to buffer the effects of highly variable ocean conditions. Simenstad et al. (1982) hypothesized that salmon use estuaries as areas of high food availability and rapid growth, areas of shelter from predators, and as a physical development and transition zone before entering the ocean.

Pacific salmon species have different juvenile freshwater life history patterns, as discussed earlier. This means that juvenile salmonids may enter the estuary at different sizes and at different stages of development (Healey 1982), reside in estuaries for various lengths of time (Table B-2), and derive different benefits from the estuary. Many migrants feed heavily, resulting in a period of good growth; in some cases this may be the highest growth rate in their life history (Simenstad et al. 1982). Chinook salmon exhibit a wide range of life history patterns resulting in several groups of chinook residing in estuaries concurrently. They may enter the estuary as fry at 1.5 inches long from March through May after a few days or weeks of freshwater residence, as older fry in May and June at 2.5 to 3.5 inches long, or as yearling juveniles in April and May at 3 to 4 inches long (Healey 1982). Coho salmon in Oregon, after spending a year or more in fresh water, enter the estuary in April and May when they are 3 to 4 inches long (Healey 1982).

Healey (1982) used three criteria to address estuary dependence by Pacific salmon: (1) rearing habitats other than estuaries that are available to the fish, (2) the proportion of the population that uses the habitats other than estuaries, and (3) the length of residence in estuaries. Based on these criteria Healey concluded that chinook salmon, because of their varied life history patterns, were most dependent on estuaries, followed by chum and coho salmon. Healey (1982) also concluded that sockeye and pink salmon were least dependent, but still used estuaries as a transition areas and feeding areas while preparing to enter the ocean.

Generally, smaller fish of all Pacific salmon species use the nearshore, shallow-water habitats in an estuary while larger fish go directly to the deeper-water, offshore areas. As the smaller fish grow they begin to use the offshore, deeper-water habitats (Healey 1982, Simenstad et al. 1982). Healey (1980) suggested that in some cases, there appears to be a threshold size determining when these fish enter deeper or higher salinity water. Thus, the nearshore, shallow-water habitats where salmon first reside, are important. Healey (1982) hypothesized that the network of intertidal marshes, subtidal weed beds, tidal creeks, and channels and shape of the basin contribute to the ability of an estuary to provide the needs of juvenile salmon, and that this network must be maintained to conserve salmon production. If these areas are reduced or degraded, then salmon must rely more on freshwater habitats to attain a larger size in order to increase their probability of marine survival (Bilton et al. 1982, USDA et al. 1993).

Coastal Oregon chinook reside in estuaries from a few weeks to 5 months. This time is used to provide some additional rearing prior to ocean entry. Time of estuary residence seems to be related to fish size and the characteristics of the available estuary habitats. Information from the Rogue River concerning estuary residence seemed to link fish size to estuary residence, with smaller fish residing longer than bigger fish. Residence time usually varies from 1 to 6

weeks. Information from returning Siuslaw River adult chinook showed that they reared in the estuary for several months (June to early September). Information from the Sixes River indicated that returning adult chinook reared in the estuary for almost 3 months (Nicholas and Hankin 1988).

In addition to juvenile salmon use of these nearshore, shallow-water estuary areas, anadromous coastal cutthroat trout (see the resident fish section of this chapter) spend a lot of time in estuarine sloughs and tidal areas (Nickelson et al. 1992). Nickelson et al. (1992) suggested that large woody debris is an important habitat component for the anadromous coastal cutthroat trout in these areas. Estuaries are also used by returning adult anadromous fish as staging areas prior to upstream migration. These tidally influenced and shallow, submerged vegetative areas are also important to fish such as the tidewater goby and the Sacramento splittail (see the resident fish section of this chapter).

The period of ocean entry is a critical phase in the life cycle of anadromous salmonids (Pearcy 1992). When salmon and steelhead smolts enter the marine environment they encounter differences in salinity, water temperatures, currents, food abundance, and predator abundance. The annual variation in these conditions encountered during early marine life may be largely responsible for much of the variation seen in marine survival. Early ocean mortality rates are high, but mortality rates lower as fish grow (Pearcy 1992). Shapovalov and Taft (1954) suggested that the bulk of the mortality suffered by coho salmon during the smolt to adult phase occurred during the first year of ocean residence. For discussions on mortality factors during ocean residency see Groot and Margolis (1991) and Pearcy (1992).

Ocean Distribution, Rearing and Feeding

The anadromous salmonids within the range of the northern spotted owl inhabit an ocean environment that is highly variable in productivity. As mentioned earlier, through employing a wide range of life history strategies a species and populations can persist in the face of these variable conditions. The boundary between the cool, nutrient-rich waters of the subarctic zone and the warm, nutrient-poor waters of the southern subtropical zone occurs off the coast of Washington, Oregon, and northern California. The shifting of this boundary affects the productivity in an area of the ocean where many stocks of anadromous salmonids, particularly coho salmon, reside while in the ocean (Pearcy 1992, Bottom et al. 1986, Fulton and LaBrasseur 1985).

Ocean migrations of salmon can cover several thousand miles (Pearcy 1992). Chinook salmon that migrate to the ocean in their first year of life usually reside in coastal waters before becoming oceangoing, while chinook salmon that migrate to the ocean as yearling fish are oceangoing soon after ocean entry (Healey 1982, 1983). Populations of spring and fall chinook salmon from northern Oregon coastal streams may migrate as far north as southeastern Alaska while chinook salmon stocks from southern Oregon and northern California distribute in the ocean off of southern Oregon and northern California (Nicholas and Hankin 1988).

Anadromous coastal cutthroat trout remain in nearshore ocean, estuaries, and bays. Southern stocks of steelhead and coho salmon may have similar distributions (Pearcy 1992), staying to feed in the areas off southern Oregon and northern California rather than migrating into the more productive subarctic zone.

Most anadromous salmonids reside in the ocean for six months to several years (Table B-2) (Pearcy 1992, Groot and Margolis 1991). Coho usually spend a maximum of 18 months in the ocean, while chinook and steelhead may spend from several months to several years in the ocean (Pearcy 1992, Groot and Margolis 1991). Anadromous coastal cutthroat trout may spend several months in the nearshore ocean but may prefer to reside in estuaries and bays while migrating to estuaries and freshwater habitats to overwinter (Behnke 1992, Pearcy 1992).

Pacific salmon usually feed on small bait fish, plankton, crustaceans, and squid during ocean rearing (Groot and Margolis 1991). Chinook salmon juveniles feed on small baitfish, crab larvae, squid, and amphipods with fish being the largest part of the diet (Healey 1991). The diet of adult coho salmon in the ocean is similar to the chinook salmon's diet except that coho eat a much higher percentage of invertebrates than do chinook (Sandercock 1991).

Anadromous Salmonid Stock Status

This discussion presents specific stock status information about the anadromous salmonid species occurring in southwestern Oregon within the range of the northern spotted owl. In some areas, specific life history information also is included.

The stock status information about coastal Oregon spring and fall chinook, coho, chum, steelhead, and anadromous coastal cutthroat trout was taken from Nickelson et al. (1992). Nickelson et al. (1992) provided the following stock status definitions for healthy and depressed stocks and stocks of special concern and unknown status.

Healthy - available spawning habitat has generally been fully used and abundance trends have remained stable or increased during the last 20 years.

Depressed - available spawning habitat has generally been underseeded or abundance trends have declined during the last 20 years or abundance trends in recent years have been generally below 20-year averages. Some of these stocks may also meet special concern status.

Special concern - population may be composed of 300 or fewer spawners or stock is at risk for interbreeding between the population and stray hatchery fish at a level in excess of the standard established by the Oregon Wild Fish Management Policy.

Unknown - insufficient data to judge status.

Because several of the river systems in Oregon have been altered by dams and other human activities, mitigation measures were sometimes used to restore fish populations and habitat affected by the activity. In many cases the mitigation was the construction of a hatchery to replace a population of wild fish or its habitat that was destroyed by the action. In some cases mitigation also took the form of the introduction of hatchery fish into an area to supplement or take the place of the wild population that occurred in the area.

Because of this mixture of wild and hatchery fish, stock status information is often described in terms of the origin of the fish stock, if known. In this document wild stocks are those that are native to the area and have little or no influence of hatchery fish in their history. Naturally produced fish are fish which are produced in the wild, but have some hatchery influence in their

past, either because of hatchery fish straying into wild fish spawning areas, or because hatchery fish releases were made in wild production areas to augment wild fish production. Natural production could also occur in areas that were recolonized by hatchery produced fish, either by hatchery strays or intentional releases of hatchery fish into the area. Hatchery fish are populations that are produced in a hatchery and return to the hatchery. The original population may have come from a wild population or another hatchery population.

Coastal Oregon River Systems

Coastal Oregon streams and rivers produce five species of anadromous salmonids including chinook, chum, and coho salmon, steelhead, and anadromous coastal cutthroat trout (Table B-3). These fish have supported ocean commercial and sport fisheries and in river sport fisheries along the Oregon coast and nearby Washington and California areas for many years. At the turn of the century, coastal Oregon streams may have produced 300,000 to 600,000 chinook salmon adults and 1 to 2 million coho salmon adults annually (Nickelson et al. 1992). During the 1930s annual production of chum salmon and steelhead is estimated at 130,000 fish and 100,000 fish, respectively (Nickelson et al. 1992). As with many wild salmon and trout populations in the Pacific Northwest, many coastal Oregon fish populations are declining (Table B-4). The current production level of chinook salmon and steelhead is about 50 percent of historic levels. Current production of coho and chum salmon may be less than 10 percent of historic levels (Nickelson et al. 1992).

Loss, simplification, and degradation of freshwater habitat; loss and degradation of estuary habitat; overfishing; and influences of hatchery fish are the general causes of the decline from historic levels (Nickelson et al. 1992). Freshwater habitat loss and degradation in some river basins was caused by splash damming, which resulted in several streams lacking in spawning material (Nickelson et al. 1992).

The following information about coastal Oregon spring and fall chinook salmon, coho salmon, steelhead, and anadromous coastal cutthroat trout is from Cooney and Jacobs (1993, 1995) and Nickelson et al. (1992). Life history information and run strength trends of coastal Oregon chinook stocks is from Nicholas and Hankin (1988) and Nickelson et al. (1992). Refer to those documents for more detailed information.

Chinook Salmon

Chinook populations along the Oregon coast display a wide variety of life history traits including variations in size, date and age of ocean entry, ocean distribution, timing of return to fresh water, and time of spawning (Nicholas and Hankin 1988). Of the coastal Oregon streams that support chinook salmon populations most support populations of fall chinook and about 33 percent of the basins have spring chinook (Table B-4). There are a few stocks that have run timing classified as summer or winter. In their review, Nicholas and Hankin (1988) grouped the summer-run fish as spring chinook and winter-run fish as fall chinook.

The major spring chinook populations on the southwestern Oregon coast occur in the Rogue and Umpqua rivers. The Rogue River population is the largest on the Oregon coast while the combined Trask and Wilson rivers populations are the second largest (Nicholas and Hankin 1988).

The Rogue River Basin is possibly the largest source of naturally produced fall chinook salmon among the coastal Oregon streams (Nicholas and Hankin 1988, ODFW 1991a). Rogue River

fall chinook spawn in the middle portions of the mainstem of the Rogue River, near Grants Pass, Oregon, and in the Applegate River Basin (Cooney and Jacobs 1993).

Nicholas and Hankin (1988) classified the various coastal Oregon chinook stocks based on fishery recovery information and on how the stocks migrated in the ocean. Spring chinook stocks north of the Rogue River were classified as north-migrating stocks, migrating north along the Washington, British Columbia, and southeastern Alaska coast. Spring chinook south of the Rogue River were classified as south-migrating fish, staying off the coast of southern Oregon and northern California. Umpqua River spring chinook were classified as north- and south-migrating stocks, residing off the coast of southern Oregon up to southeastern Alaska. Oregon coastal fall chinook from the Nehalem River south to the Sixes River were classified as north-migrating stocks while fall chinook salmon from Euchre Creek south to the Winchuck River were south-migrating stocks (Nicholas and Hankin 1988).

The peak counts per mile surveyed of north-migrating stocks have shown an increasing trend since the mid-1950s (Cooney and Jacobs 1993,1995), while counts of the south-migrating stocks have varied widely and shown a decreasing trend since the record high count in 1972 (Cooney and Jacobs 1993). Carcass surveys have shown a decreasing trend in the middle portions of the Rogue River fall chinook salmon spawning grounds. The average peak count of coastal Oregon fall chinook in 1993 was 43 adult fish per mile, which was 96 percent of the 44-year average of 45 fish per mile (Cooney and Jacobs 1993). The coastal Oregon fall chinook salmon stocks south of the town of Bandon, Coos County, are designated as sensitive-critical species by the state (OOFW 1995).

Coho Salmon

Coho salmon are produced in most coastal Oregon streams and rivers. Surveys are conducted on more than a dozen river systems and represent more than 4,600 miles of stream available for coho salmon spawning (Cooney and Jacobs 1993, page 21 Table 5). The Nehalem, Siuslaw, Umpqua, Coos, and Coquille river systems are major producers of coho salmon along the Oregon coast, based on miles of spawning habitat available (Cooney and Jacobs 1992, 1993, and 1995).

Estimates of spawning stock size for coho salmon in coastal Oregon river basins in 1993 was 44,265 fish. In 1990 and 1991 the estimates were 99,550 and 128,197 fish, respectively. The average peak counts of coho salmon in coastal Oregon streams have declined sharply from the mid-1960s to the mid-1970s, and peak counts have remained at these low levels. The 44-year average was 20 fish per mile. The 1993 average peak count of 18 fish per mile was 20 percent below the 44-year average and is the highest peak count since 1988 (21 fish per mile) (Table B-5).

The state of Oregon has designated the stocks of coho salmon statewide as sensitive-critical species (ODFW 1995). In July 1993 the NMFS was petitioned by Oregon Trout and several environmental and conservation groups to list 40 coho salmon populations occurring along the Oregon coast and in the Columbia River as endangered or threatened under the ESA. Subsequently, the NMFS was petitioned in October 1993 by the Pacific Rivers Council and several environmental, conservation, and recreational fishing groups to list the coho salmon throughout its range in Washington, Oregon, Idaho, and California as threatened or endangered under the ESA; a status review was conducted and NMFS subsequently proposed several coho

stocks as endangered or threatened under the ESA. The NMFS is expected to make the final determination on coho listings in October 1996.

Pink Salmon

Information about pink salmon occurrence in the coastal streams of Oregon is very scant (Frissell 1994 personal communication). Records from harvest along the Oregon coast indicate that pink salmon were not a contributor to the fisheries along the coast and probably are an indicator that significant populations did not occur in Oregon coast streams.

Steelhead

Steelhead are produced in almost all coastal Oregon streams (Table B-3). The ODFW has provisionally identified 6 populations of summer steelhead and 81 populations of winter steelhead (Nickelson et al. 1992). Ocean conditions may play a major role in determining the yearly population levels of Oregon coastal steelhead stocks since steelhead populations across a broad geographic range show similar trends in abundance (Nickelson et al. 1992). Trends in population levels indicate that factors such as freshwater habitat, stock differences, and angler success are affecting population levels of these stocks in some years. While ocean conditions are probably an important factor, declining freshwater habitats during the last century have decreased the productivity of wild coastal Oregon steelhead stocks.
The NMFS was petitioned in September 1993 to list the Deer Creek (a tributary of the Stillaguamish River in Washington) as threatened or endangered under the ESA. During the status review, NMFS determined that all west coast steelhead stocks should be reviewed. Subsequently NMFS has determined that several stocks warrant protection under the ESA and proposed on July 31, 1996 to list all steelhead populations in southwest Oregon as endangered or threatened.

Anadromous Coastal Cutthroat Trout

Most coastal Oregon streams produce anadromous coastal cutthroat trout (Table B-3). The ODFW has provisionally identified 92 populations of wild anadromous coastal cutthroat trout along the Oregon coast (Nickelson et al. 1992).

As in other areas of the Pacific Northwest, anadromous coastal cutthroat trout populations in Oregon seem to be declining (Nickelson et al. 1992, Nehlsen et al. 1991). The state of Oregon has designated Umpqua River coastal cutthroat trout populations that occur below impassable natural barriers as sensitive-vulnerable (ODFW 1995). Information about the population levels of anadromous coastal cutthroat trout in Oregon streams is sparse, but fish counts at dams and creel censuses seem to show widespread decline (Nickelson et al. 1992). In analyses conducted by the ODFW (cited in Nickelson et al. 1992), using limited information usually collected incidentally with other activities along the central coast during the 1980s, a declining trend in population density was not significant. But these data do not provide a picture of the long-term trend. It is believed that by 1980 the populations were already at low levels due to habitat loss. Counts of fish over Winchester Dam provide information about anadromous coastal cutthroat trout from the North Umpqua River. This is considered the best long-term information about any of the anadromous coastal cutthroat trout populations in Oregon (Nickelson et al. 1992). Counts at Winchester Dam suggest a serious decline in the population. From 1946 to 1956 counts averaged about 950 fish annually, ranging from about 400 to 1,800 fish. Hatchery releases were made to supplement the wild populations. By 1960 the counts of

wild fish were less than 100, and since 1980 counts have exceeded 100 fish only twice. This population is now considered near extinction (Nickelson et al. 1992, Nehlsen et al. 1991). The NMFS was petitioned to list the North Umpqua River and South Umpqua River anadromous coastal cutthroat trout as endangered or threatened under the ESA on March 31, 1993, in July 1993 the NMFS found the petition was warranted and a status review was started. The agency was petitioned in August 1993 to emergency list the North and South Umpqua River anadromous coastal cutthroat trout as threatened or endangered under the ESA. Reasons for the petition to emergency list the stock were "new circumstances and scientific information that warrant emergency listing" (ONRC/The Steamboaters 1993, 1). On July 8,1994, NMFS proposed to list the Umpqua River coastal cutthroat trout (anadromous and resident life history types) as endangered under the ESA due to the similarity in the life history types (Johnson et al. 1994). On July 31, 1996, NMFS announced a final determination to list the species as endangered. The listing is effective August 31, 1996.

Anadromous coastal cutthroat trout populations in coastal Oregon streams show a wide variation in life history strategies (see resident fish section of this chapter). These differences may reflect adaptations to the conditions in the local stream or river system (Nickelson et al. 1992). Anadromous coastal cutthroat trout generally spawn in small (first- and second-order streams) along the Oregon coast from December through February (Nickelson et al. 1992).

Table B- 1: Fish Species that are Federal Threatened, Endangered, or Candidate; State Threatened, Endangered, or Sensitive; or of AFS Special Concern in Southwestern Oregon

	Status[a,b]			
Species	**Life Cycle**	**Fed**	**OR**	**AFS[c]**
Pacific lamprey *(Lampetra tridentata)*	A	SV		
Bull trout (*Salvelinus confluentus)*	R	C	SC	X
Coastal cutthroat trout (*Oncorhynchus clarki clarki)*	A			
Umpqua River		E	SC	X
Other Stocks				X
Redband trout *(Oncorhynchus mikiss spp.)*	R		SV	X
Summer steelhead *(Oncorhynchus mikiss spp.)*	A	PrT		X
Winter Steelhead *(Oncorhynchus mikiss spp.)*	A	PrT		X
Fall chinook salmon *(Oncorhynchus tshawytscha)*	A		SC	X
Spring chinook salmon *(Oncorhynchus tshawytscha)*	A			X
Coho salmon (*Oncorhynchus kisutch)*	A	PrE	SC	X
Oregon chub *(Oregonichthys crameri)*	R	E	SC	X
Umpqua chub *(Oregonichthys kalawatseti)*	R		SV	
Jenny Creek sucker *(Catostomus rimiculus spp.)*	R		SR	X
Lost River sucker *(Deltistes luxatus)*	R	E	SE	X
Shortnose sucker *(Chasmistes brevirostris)*	R	E	SE	X
Slender sculpin *(Coltus tenuis)*	R			X

Life Cycle: R = resident; A = anadromous, OR = Oregon

[a]Federal status: E = endangered, T = threatened, Pr = proposed, C = candidate, C1= category 1 candidate, C2 = category 2 candidate, U.S. Fish and Wildlife Service candidates that need additional information to propose as threatened or endangered under the Endangered Species Act.

[b]State status:OR: SC = sensitive (critical), SV = sensitive (vulnerable), SR = sensitive (rare), SU = sensitive (undetermined). Sources (states): Oregon Department of Fish and Wildlife (1995).

[c]AFS (American Fisheries Society) Status: For this table species of concern include AFS threatened, endangered, of special concern, and at risk of extinction taken from Williams et al. (1989), Nehlsen et al. (1991), and Higgins et al. (1992).

Table B- 2: General Spawning Areas and Freshwater, Ocean and Estuarine Residency Times of Anadromous Salmonids (after Pearcy 1992)

Species	Spawning Areas[a]/Residence[b]	Freshwater Residence[a]	Ocean Residence[b]	Estuarine
Chinook salmon	Streams, rivers	1 Month to 2 Years	6 mos to 6 yrs	days to mos
Coho Salmon	Streams	1 month to 2 years	6 mos to 6 yrs	days to mos
Steelhead	Streams, rivers	1 to 4 years	Mos to 4 yrs	Less than a mo
Sea-run coastal cutthroad	Usually small coastal streams	less than a month	1 to 6 yrs	2 to 6 mos

[a] Groot and Margolis 1991.

[b] Pearcy 1992.

Table B- 3: Occurrence of Anadromous Salmonids in Major Oregon Coastal Basins (Nickelson et al. 1992)

Basin	Spring Chinook	Fall Chinook	Coho	Summer/Winter Steelhead	Sea-run Steelhead	Cutthroat
Necanicum R.	-	H	x	-	x	x
Elk Cr.	-	-	x	-	x	x
Nehalem R.	x	x	x	-	x	x
Tillamook Bay						
Miami R.	-	x	x	-	x	x
Kilchis R.	x	x	x	H	x	x
Wilson R.	x	x	x	x	H	x x
Trask R.	x	x	x	-	x	x
Tillamook R.	-	x	x	-	x	x
Nestucca R.	x	x	x	H	x	x
Neskowin Cr.	-	x	x	-	x	x
Salmon R.	-	x	x	-	x	x
Siletz R.	x	x	x	x	x	x
Yaquina R.	-	x	x	-	x	x
Beaver Cr.	-	x	x	-	x	x
Alsea R.	x	x	x	-	x	x
Yachats R.	-	x	x	-	x	x
Siuslaw R.	x	x	x	-	x	x
Siltcoos R.	-	-	x	-	x	x
Tahkenitch Cr.	-	-	x	-	x	x
Umpqua R.	x	x	x	x	x	x
Smith R.	-	-	x	-	x	x
Tenmile Cr.	-	-	x	-	x	x
Coos R.	-	x	x	-	x	x
Coquille R.	x	x	x	-	x	x
New R.	-	x	x	-	x	x
Sixes R.	-	x	x	-	x	x
Elk R.	-	x	x	-	x	x
Euchre Cr.	-	x	x	-	x	x
Rogue R.	x	x	x	x	x	x
Hunter Cr.	-	x	x	-	x	x
Pistol R.	-	x	x	-	x	x
Chetco R.	-	x	x	-	x	x
Winchuck R.	-	x	x	-	x	x

H indicates a population comprised of hatchery fish only.
- Dash indicates data not available or species not found in this basin.

Table B- 4: Oregon Coastal Wild Anadromous Salmonid Provisional Population Status (Nickelson et al. 1992)

Stock Status	Spring Chinook	Fall Chinook	Coho	Winter Steelhead	Summer Steelhead
Healthy[1]	5	25	6	5	1
Depressed[2]	2	6	41	19	2
Special Concern[3]	4	4	2	1	0
Unknown[4]	1[b]	6[b]	6	0	0
Total	12	41	55	25	3

[1] Healthy - available spawning habitat has generally been fully used and abundance trends have remained stable or increased during the last 20 years.

[2] Depressed - available spawning habitat has generally been fully used or abundance trends have declined during the last 20 years or abundance trends in recent years have been generally below 20-year averages. Some of these stocks may also meet special concern status.

[3] Special concern - population may be composed of 300 or fewer spawners or stock is at risk for interbreeding between the population and stray hatchery fish at a level in excess of the standard established by the Oregon Wild Fish Management Policy. (Nickelson et al. 1992)

[4] Unknown - insufficient information to rate stock status.

[b] May include some populations that are not viable.

Table B- 5: Average Peak Number of Fish per Mile for Oregon Coastal Coho Salmond Observed in Standard Stream Segments, 1950-93[7]Values in parentheses include adult coho salmon from public and/or private hatcheries. (Cooney and Jacobs 1995; page 57.)

	Coho Salmon			
Year	Miles	Jacks	Adults	Total
1950	34.1	3	21	24
1951	36.1	7	55	61
1952	36.1	5	54	58
1953	36.1	2	15	16
1954	36.1	5	28	33
1955	36.1	2	24	25
1956	36.1	8	29	37
1957	36.1	2	35	37
1958	33.5	2	12	14
1959	34.2	1	29	31
1960	38.9	5	11	16
1961	38.9	8	31	38
1962	38.4	4	26	30
1963	42.2	5	16	21
1964	42.7	7	44	50
1965	42.7	7	33	40
1966	42.7	3	24	26
1967	40.7	10	22	32
1968	31.6	1	18	19
1969	42.7	6	19	25
1970	42.7	3	24	27
1971	40.7	2	30	32
1972	37.3	4	11	14
1973	40.1	2	17	19
1974	38.7	7	13	20
1975	25.1	4	16	20
1976	21.9	4	18	21
1977	23.1	1	6	8
1978	24.4	3	8	11
1979	24.8	2	18	20
1980	41.7	3	12	15
1981	54.8	2	7	9
1982	54.8	7	15	21
1983	54.8	2	6	8
1984	54.8	3	16	19
1985	54.8	5	17	22
1986	54.5	3	17	20
1987	52.7	4	10	14
1988	52.7	2	19	21
1989	52.7	3	14	17
1990	52.7	2	8	9
1991	52.7	2	12	14
1992	53.0	3	12	14
1993	53.0	1	16(17)	18

- Dash indicates data not available.

[7] Values in parentheses include adult coho salmon from public and/or private hatcheries (Cooney and Jacobs 1995; page 57).

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APPENDIX C: NATIVE AMERICAN TRIBAL CONSULTATION

Included in South Cascades Late Successional Resource Assessment.

APPENDIX D: SERAL STAGE CLASSIFICATION

Included in South Cascades Late Successional Reserve Assessment.

APPENDIX E: FIRE AND FUEL ASSUMPTIONS

Included in South Cascades Late Successional Reserve Assessment.

APPENDIX F: INSECT AND DISEASES IN THE LSRS

Included in South Cascades Late Successional Reserve Assessment.

APPENDIX G: TEAM CHARTER

Included in South Cascades Late Successional Reserve Assessment.

APPENDIX H: SUSTAINABLE LATE SERAL VEGETATION IN THE SOUTH CASCADES LSRS

Included in South Cascaded Late Successional Reserve Assessment.

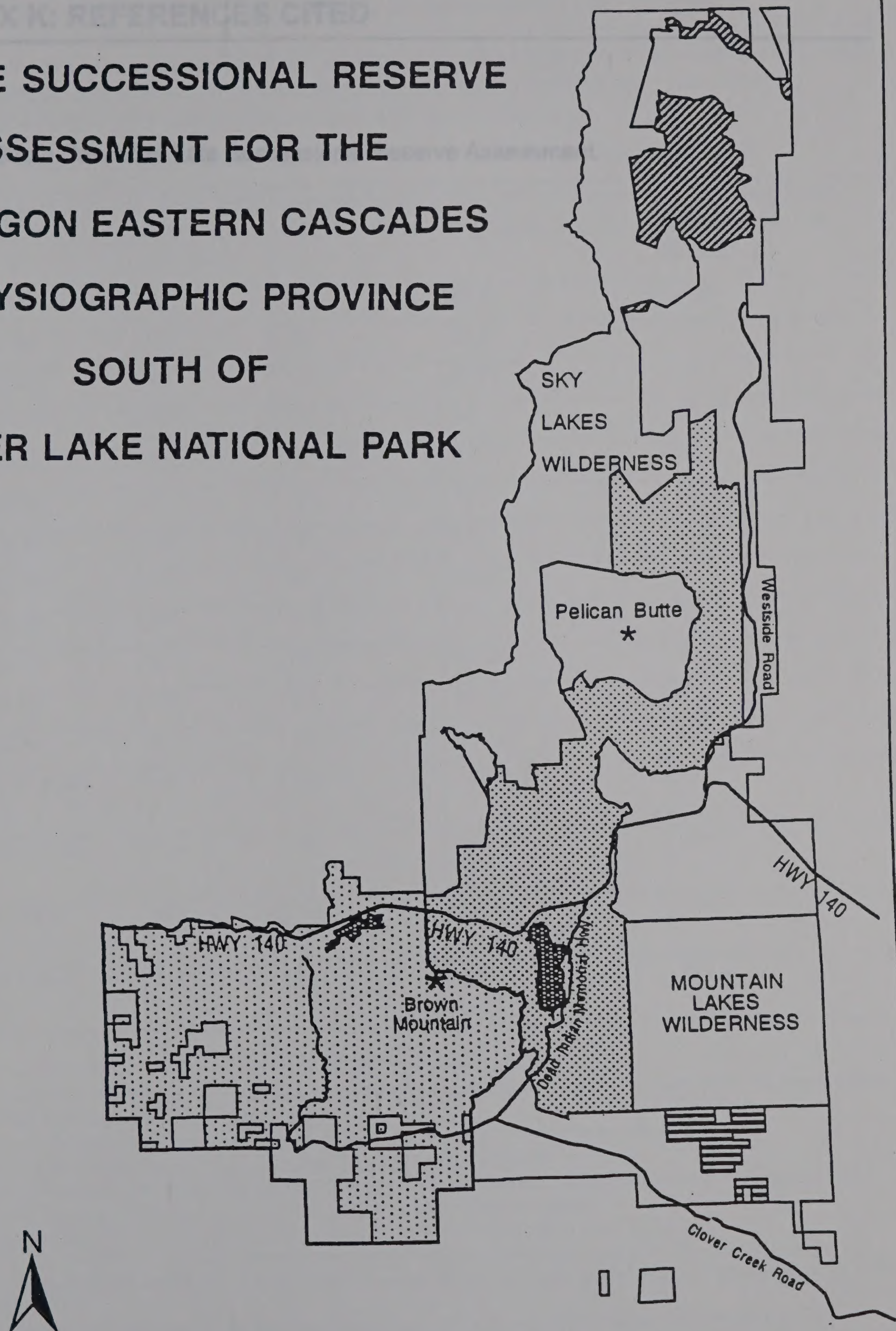
APPENDIX I: AQUATICS TABLES

Included in South Cascades Late Successional Reserve Assessment.

APPENDIX J: LATE SUCCESSIONAL RESERVE ASSESSMENT FOR THE OREGON EASTERN CASCADES PHYSIOGRAPHIC PROVINCE SOUTH OF CRATER LAKE NATIONAL PARK

Following is the most recent version of the *Late Successional Reserve Assessment for the Oregon Eastern Cascade Physiographic Province South of Crater Lake National Park,* including the LSRA review memorandum from the Regional Ecosystem Office dated September 5, 1997.

LATE SUCCESSIONAL RESERVE ASSESSMENT FOR THE OREGON EASTERN CASCADES PHYSIOGRAPHIC PROVINCE SOUTH OF CRATER LAKE NATIONAL PARK



APPENDIX K: REFERENCES CITED

Included in South Cascades Late Successional Reserve Assessment.

APPENDIX L: PROJECTED COVER IN MANAGED STANDS

Managed yield tables were used to obtain average tree sizes in order to estimate the projected cover percentage associated with three age classes in each Plant Series. The following presents the average tree size assumptions and cover calculations.

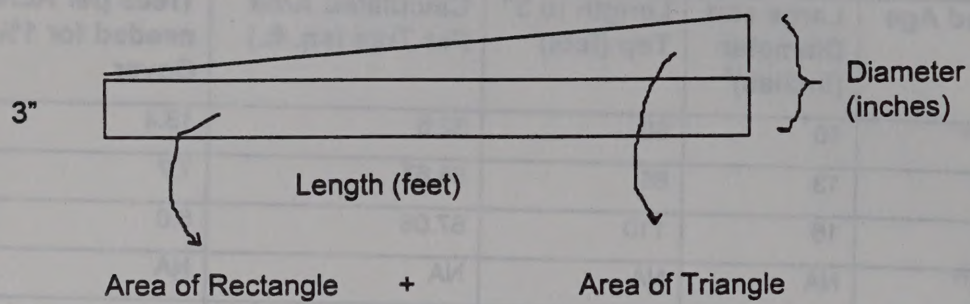
Table L-1: Individual Tree Size Assumptions and Projected Cover

Yield Table and Age	Large end Diameter (inches)[8]	Length to 3" Top (feet)[9]	Calculated Area Per Tree (sq. ft.)	Trees per Acre needed for 1% Cover
CF/CR, Age 40[10]	10	60	32.5	13.4
CF/CR, Age 60	13	85	56.67	7.7
CF/CR, Age 80	16	110	87.08	5.0
CM/CE, Age 40[11]	NA	NA	NA	NA
CM/CE, Age 60	NA	NA	NA	NA
CM/CE, Age 80	9	30	15.00	29
CH/CW, Age 40[12]	12	60	37.5	11.6
CH/CW, Age 60	17	90	75.00	5.8
CH/CW, Age 80	27	105	131.25	3.3
CD/CP, Age 40	9	60	30.00	14.5
CD/CP, Age 60	12	80	50.00	8.7
CD/CP, Age 80	17	95	79.17	5.5
Western Redcedar, THPL[13]	NA	NA	NA	NA
Oregon White Oak, QUGA[14]	NA	NA	NA	NA
Lodgepoie Pine, PICO[15]	NA	NA	NA	NA
Ponderosa Pine, PIPO[16]	NA	NA	NA	NA

[8] One inch was added to yield table values to convert DBH to stump height where DBH was <20". Two inches were added where DBH was equal or greater than 20".
[9] Ten feet was subtracted from yield table values to convert from total tree height to length at 3" top.
[10] In managed yield tables, the high elevation true fir series were combined.
[11] The amount of density management treatment is expected to be very low overall, and then only in stands >70.
[12] White fir and Western Hemlock Series were combined in managed yield tables.
[13] No managed yield table data available for this Series. The CH/CW Group is used in this table.
[14] Data were unavailable for this Plant Series. This Series is most closely represented by the CD/CP Group, therefore those numbers are used. For the eastern portion of LSR 227, use guidelines from the Winema NF LSR Assessment.
[15] Data unavailable for these Series. In the South Cascades LSR network, these Series are mostly within the eastern portion of LSR 227, therefore use LWM guidelines from the Winema NF LSR Assessment.

Calculations of projected cover per tree

The following formula was used for all ages and yield table groups:



Sq Ft./Tree = (3/12 * Length in Feet) + (((Diameter in inches/12 - 3/12) * Length in Feet)/2)

16 Data unavailable for these Series. In the South Cascades LSR network, these Series are mostly within the eastern portion of LSR 227, therefore use LWM guidelines from the Winema NF LSR Assessment.

REGIONAL ECOSYSTEM OFFICE

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MEMORANDUM

DATE: September 5, 1997

TO: Robert W. Williams, Regional Forester, Region 6, Forest Service

FROM: Donald R. Knowles, Executive Director Don Knowles

SUBJECT: Regional Ecosystem Office Review of the Winema National Forest's Oregon Eastern Cascades Physiographic Province Late-Successional Reserve Assessment

Summary
The Regional Ecosystem Office (REO) and the interagency Late-Successional Reserve (LSR) Work Group have reviewed the Oregon Eastern Cascades Physiographic Province Late-Successional Reserve Assessment (LSRA). The REO finds that the LSRA, with the assumptions listed below, provides sufficient framework and context for future projects and activities within the LSR. Future silvicultural activities described in the LSRA (as discussed below) that conform to the LSRA criteria and objectives and that are consistent with the Standards and Guidelines (S&Gs) in the Northwest Forest Plan (NFP) are exempt from further project-level REO review.

Basis for the Review
Under the S&Gs for the NFP, a management assessment should be prepared for each large LSR (or group of smaller LSRs) before habitat manipulation activities are designed and implemented. As stated in the S&Gs, these assessments are subject to the REO review. The REO review focuses on the following:

1. The review considers whether the assessment contains sufficient information and analysis to provide a framework and context for making future decisions on projects and activities. The eight specific subject areas that an assessment should generally include are found in the NFP (S&Gs, page C-11). The REO may find that the assessment contains sufficient information or may identify topics or areas for which additional information, detail, or clarity is needed. The findings of the review are provided to the agency or agencies submitting the assessment.

2. The review considers potential treatment criteria and treatment areas addressed in the LSRA. When treatment criteria are clearly described and their relationship to achieving desired late-successional conditions are also clear, subsequent projects and activities within the LSR(s) may be exempted from the REO review, provided they are consistent with the LSRA criteria and S&Gs. The REO authority for developing criteria to exempt these actions is found in the S&Gs (pages C-12, C-13, and C-18).

Scope of the Assessment and Description of the Assessment Area
The REO reviewed the LSRA for conformity with the eight subject areas identified in the S&Gs (page C-11). Several initial questions regarding the desired future conditions and proposed silvicultural treatments were resolved in subsequent meetings and conference calls between the work group and Klamath Ranger District staff of the Winema National Forest. The LSRA was revised to reflect the results of those meetings and conversations and the revised portions of the LSRA were resubmitted by the Ranger District. The REO finds that the revised LSRA provides a sufficient framework and context for making future decisions on projects and activities within the LSR.

The LSRA addresses approximately 61,000 acres within LSRs RO227 (eastern portion, 48,669 acres; the western portion is within the Ashland Ranger District and is discussed only as it relates to the management of the eastern portion), RO228 (2,817 acres), and RO229 (9,219 acres). The LSRs are located within the Klamath Ranger District. Plant associations include: mixed conifer (11% of the LSRs), white fir (22%), Shasta red fir/white fir (50%), Shasta red fir/mountain hemlock (11%), and lodgepole pine (3%). Approximately 36% of the LSRs is in an old-growth condition.

The assessment successfully describes the conditions and processes within and surrounding the LSRs. The assessment details existing and expected future structure, as well as desired future conditions. It describes interior habitat, present conditions and those expected in 50 years when the LSRs will be fully functional. Connectivity within the LSR and with adjacent LSRs and the presence of known and potential Survey and Manage Species are also thoroughly discussed.

Assumptions and Clarifications
Members of the work group visited portions of the LSRs in order to more fully understand the proposals described in the LSRA. They observed proposed treatment areas and discussed possible treatments that would be undertaken in accordance with the LSRA. Further telephone conversations were held with members of the Forest staff to clarify unresolved questions. The Forest submitted another revised LSRA which included changes and clarifications that arose from the field trip and follow-up discussions. The following provides a synopsis of those changes, as understood by the interagency work group and the REO:

- ***Desired Future Condition***. Although the LSRs are expected to be fully functional within 50 years, there will be areas where large trees are not present and the desired large tree and snag levels may not be achieved during that time period.

  Specific late-successional habitat characteristics that are obtainable for the LSRs include: canopy closure of 56% or greater; retention of large diameter (>25" dbh) Douglas-fir, ponderosa pine, and/or sugar pine (averaging a minimum of 1-10 trees per acre, while striving to retain the largest number supportable); and coarse woody debris (CWD) of less than 3" in diameter will be 12 tons per acre or less.

- ***Landscape Distribution of Habitat***. The landscape distribution of habitat for these LSRs is classified into three principal characteristics: late-successional areas meeting nesting, roosting, and foraging (NRF) requirements of the northern spotted owl (at least 50% of the LSRs); late-successional habitat not meeting NRF and other habitat meeting dispersal requirements of the northern spotted owl; and other habitat or "open" areas. These three characteristics are described as follows:

  - *Late-Successional Areas Meeting NRF*. This habitat (which will comprise at least 50% of the LSRs) will occur in white fir and Shasta red fir stands and will be evenly distributed across the landscape.

  - *Late-Successional Habitat Not Meeting NRF and Other Habitat Meeting Dispersal Requirements*. Approximately 25% of the landscape will consist of areas that are late-successional habitat but are not NRF habitat (e.g., Shasta Red Fir - Mountain Hemlock plant association), cannot sustain high-stand densities, are managed for bald eagle habitat, are recovering from past harvest (that will be in transition from dispersal to NRF conditions), and areas not capable of sustaining NRF conditions but will maintain sufficient canopy closure and tree size to meet dispersal requirements.

  - *Other Habitat or "Open" Areas*. No more than 25% of the LSRs will be in open areas that include non-forested lands, areas of past harvest or disturbance, and areas in which stand canopy is too sparse or tree size to small to meet dispersal requirements.

- ***Stand-Level Criteria for Developing Appropriate Treatments.***
  - *Thinning.* Thinning to reduce the risk of fir engraver mortality in white fir and mixed conifer associations, where white fir comprises 60% of the basal area. Although usually trees 7-14" in diameter will be removed, occasionally trees up to 21" will be removed to accomplish the treatment objectives.

  - *Fuel Treatments.* Salvage sales and/or hand fell and pile treatments may be used. when small diameter CWD levels are sufficient and high-snag levels indicate future risk of fuel buildup. This treatment would typically be employed where Armillaria root rot or fir engraver beetles have created high-snag levels. In other cases, infrequent blowdown events may create high-hazard fuels.

- ***Commercial Treatment Summary.***
  - Silviculture projects in the LSRs will be designed primarily to reduce the risk of loss of late-successional values. Treatment will focus on fir engraver risk, western pine beetle risk, and fire hazard. Minor amounts of other risk treatments and enhancement treatments may occur.

  - The preference shall be to treat young stands for promotion and retention of older-stand characteristics realizing that not every eligible stand will be treated in order to maintain landscape-level stand diversity.

  - The treatment acreages shown on Table 12 are not additive because more than one treatment may be applied to the same acres.

  - Because of the amount of stands in various reserve allocations (riparian reserves, semi-primitive recreation areas, 100-acre unmapped LSRs, etc.), 50-60% of the "at risk" stands in any particular watershed will not be treated for fir engraver risk.

  - Culturing treatments for western pine beetle may also include areas being treated for fir engraver. Culturing treatments may also occur in Shasta red fir stands containing remnant pines stressed by dense fir under stories.

  - Treatments to reduce fire risk will most often occur in white fir and mixed confer stands in conjunction with fir engraver treatments.

  - Salvage activities may be considered in stands where stand replacing events exceed 10 acres and where the downed wood exceeds the identified CWD targets (page 58) and impedes new stand establishment. Salvage activities may also be utilized to remove hazard trees that threaten public safety or property.

  - The number of acres treated for fir engraver (per decade) will be <5,000 (Figure 12).

Conclusions
Based on the discussion presented in the final LSRA, the REO finds that the LSRA provides sufficient framework and context for future projects and activities within the LSR. Silvicultural activities described in the LSRA which are consistent with the S&Gs and the treatment criteria identified in the assessment as discussed above, are exempted from future project-level REO review. Please provide the REO with a copy of the revised final LSRA.

cc:
REO, RIEC
Arnie Holden, R-6
Robert Shull, District Ranger, Klamath District, Winema National Forest
Phil Jahn, Silviculturist, Klamath District, Winema National Forest

988/ly

The LSRA addresses approximately [illegible] acres [illegible] (western portion [illegible]) [illegible] of the eastern portion [illegible] Klamath Ranger District [illegible] Shasta red fir stands [illegible] Approximately 38% of the LSRs is in an old-growth condition.

The [illegible]

[illegible] Managed Species are also thoroughly discussed.

[illegible]

- *Desired Future Condition.* [illegible] there will be areas where large trees are not present and the desired large tree and snag levels may not be achieved during that time period.
- [illegible] Specific late-successional habitat characteristics that are [illegible] closure of 55% or greater, retention of large diameter [illegible] sugar pine averaging a minimum of [illegible] trees per acre [illegible]
- *Landscape Distribution of Habitat.* The landscape distribution of habitat [illegible] (NRF) requirements of the northern spotted owl (at least 50% of the [illegible]) not meeting NRF and other habitat meeting dispersal requirements of the [illegible] spotted owl, and [illegible]
- [illegible] will occur in white fir and Shasta red fir stands and will be evenly distributed across the landscape.
- *Late-Successional Habitat* [illegible] Approximately 25% of the landscape will consist of areas that are late-successional habitat but are not NRF habitat [illegible]
- *Other Habitat or "Open" Areas.* No more than 25% of the LSRs will be in open areas [illegible] non-forested lands, areas of past harvest or disturbance, and areas in which stand canopy is too sparse or tree size too small to meet dispersal requirements.

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LATE SUCCESSIONAL RESERVE ASSESSMENT
FOR THE
OREGON EASTERN CASCADES PHYSIOGRAPHIC PROVINCE
SOUTH OF CRATER LAKE NATIONAL PARK

I. INTRODUCTION

On April 13, 1994, the Secretaries of Agriculture and Interior signed the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl (ROD). This decision amended existing Forest Plans and created new land allocations. The amendment allocated 60,967 acres to Late Successional Reserve (LSR) in the Oregon Eastern Cascades physiographic province south of Crater Lake National Park. All of these LSR lands fall within the boundaries of the Klamath Ranger District on the Winema National Forest. "These reserves, in combination with the other allocations and standards and guidelines, will maintain a functional, interactive, late-successional and old-growth forest ecosystem. They are designed to serve as habitat for late-successional and old-growth related species including the northern spotted owl" (USDA, 1994).

The ROD specifies that "a management assessment should be prepared for each large Late Successional Reserve (or group of smaller Late Successional Reserves) before habitat manipulation activities are designed and implemented." (Standards & Guidelines pg. C-11). LSR lands located in the Oregon Eastern Cascades physiographic province south of Crater Lake National Park include: R0229 (9,219 acres); R0228 (2,817 acres); and the eastern portion of R0227 (48,669 acres). These lands have similar ecology and management concerns. They will be managed collectively and are discussed in detail in this assessment. The eastern province LSR lands will be referred to as the OECP (Oregon Eastern Cascades Province) LSR's throughout this document. (See Map A.)

The western portion of R0227 (52,837 acres) is located in the Oregon Western Cascades physiographic province on the Ashland Ranger District of the Rogue River National Forest. Because climate, vegetative conditions, and management issues are different in the western province, this portion of R0227 will be discussed only as it relates to management of the eastern LSR lands. The focus will be on broad-scale functions and concerns, such as habitat connectivity, species dispersal, and fire hazard. This document will not describe past and present uses, vegetative conditions, nor management guidelines for the western portion of LSR R0227 in any detail.

An interim assessment for the OECP LSR's was developed in 1995. Recommendations in the interim assessment have been successfully used to guide management on the Klamath Ranger District since that time. This document represents the final refined version of the LSR assessment for R0229, R0228, and the eastern half of R0227. An assessment for LSR's located in southwest Oregon (the South Cascades assessment) is currently being developed. When completed, this second document will also discuss LSR R0227 in its entirety.

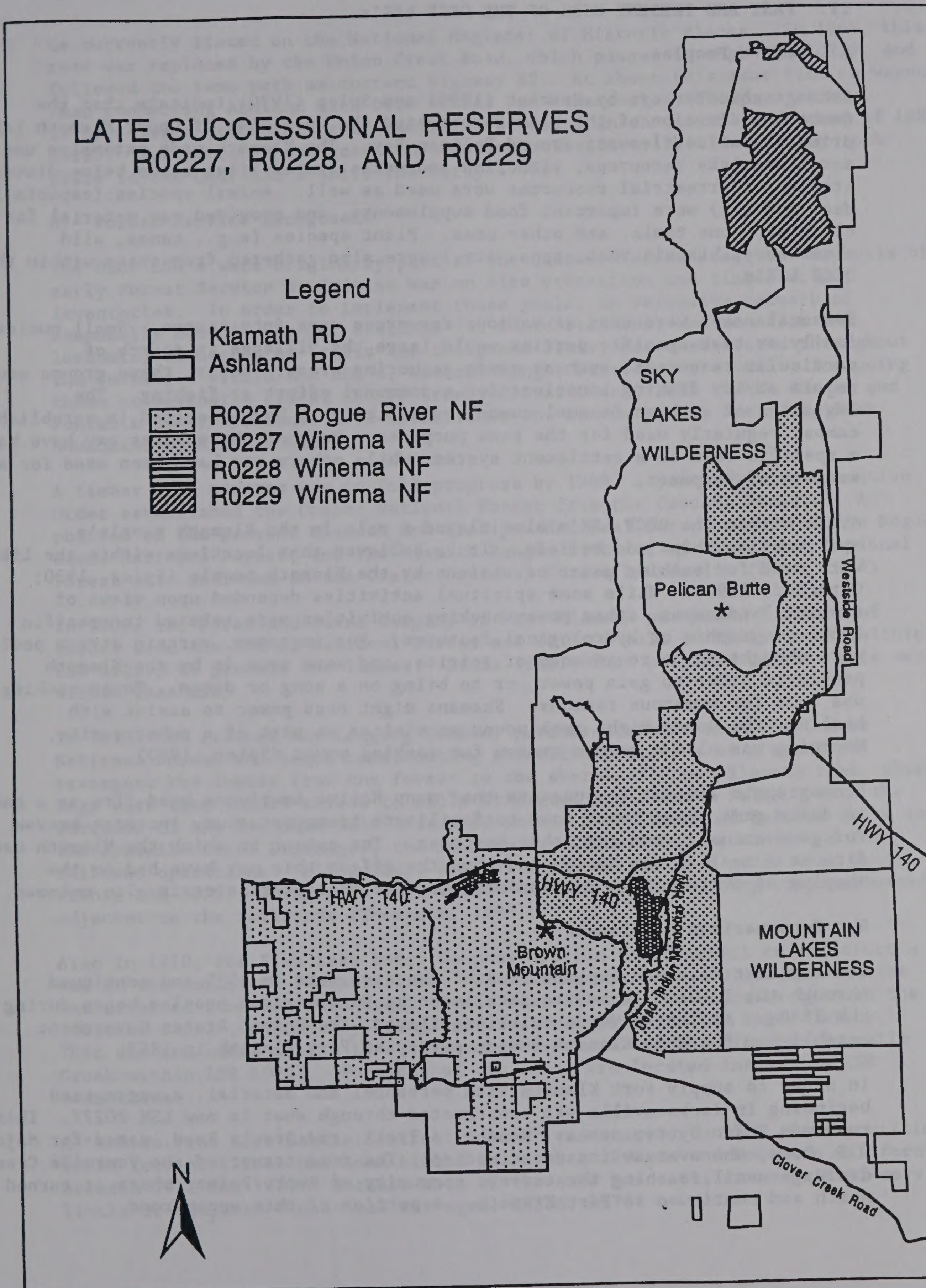
This assessment is a mid-level planning document and is not project specific. The purpose of this assessment is to:

1) Paint a picture of past and present uses and vegetation conditions in the OECP LSR's.
2) Develop a process for assessing the complex ecosystems within the OECP LSR's and outline criteria for developing appropriate ecosystem treatments to maintain or enhance late seral conditions.
3) Identify areas at risk to loss from catastrophic events.
4) Outline ways to monitor and evaluate activities to ensure they are carried out as intended and achieve desired results.

The northern spotted owl and bald eagle are currently the only Federally-listed terrestrial species known to occur in the OECP LSR's. These two species are management indicators for old growth forest in the Winema Land and Resource Management Plan. Extensive data collection and analysis have been done to characterize and map their habitats on the Klamath Ranger District. For these reasons, existing models of spotted owl and bald eagle habitat were used in this analysis to help determine desired conditions in the OECP LSR's, and assess effects of potential treatments.

Other species of management concern are discussed in Section III. The Matrix of Interactions and Monitoring processes described in Sections IX and X will be used in future analyses of habitat conditions for multiple species.

The treatments and processes described in this document are based on the best knowledge we have today. This document will be amended to reflect monitoring results and new scientific information as they become available.



MAP A. LOCATION OF LATE SUCCESSIONAL RESERVES R0227, R0228, AND R0229.

II. PAST AND PRESENT USES OF THE OECP LSR's

A. Native Peoples

Ethnographic surveys by Gatchet (1890) and Spier (1930) indicate that the Gumbotkni division of the Klamath occupied the west side of Upper Klamath Lake, primarily at settlements around Pelican Bay. The Klamath made extensive use of marsh and lake resources, with fish and wokas (water lily) seeds being dietary staples. Terrestrial resources were used as well. Animal species (especially deer and elk) were important food supplements, and provided raw material for clothing, bone tools, and other uses. Plant species (e.g., camas, wild strawberry, biscuit root, apos, etc.) were also gathered from areas within the OECP LSR's.

Seasonal camps were used as various resources came into season. Small nuclear family or task-specific parties would leave the villages in search of particular resources, such as camas gathering areas. Later, these groups would rejoin at key fishing locations for a communal effort at fishing. The logistics of such an "annual round" were likely to have resulted in established camps, regularly used for the same purposes. Many of these sites may have had a specific role in a settlement system, while others may have been used for a variety of purposes.

Areas within the OECP LSR's also played a role in the Klamath people's spiritual worships and beliefs. It is believed that locations within the LSR's were used for seeking power or visions by the Klamath people (Spier, 1930; Gatschet, 1890). While some spiritual activities depended upon views of distant landscapes, other power-seeking activities were related to specific local geographic or hydrological features. For instance, certain stream pools were thought to be residences of spirits, and were swum in by the Klamath people in order to gain power, or to bring on a song or dream. Power seeking was done for numerous reasons: Shamans might need power to assist with healing, the young might seek power or visions as part of a puberty rite. Mourning was also a common reason for seeking power (Spier, 1930).

Ethnographic literature suggests that many Native Americans used fire as a tool to drive game, keep brush down to facilitate transportation, increase browse for game animals, and for other purposes. The extent to which the Klamath used fire as a tool is not known, and thus the effect this may have had on the shaping of current Late Successional Reserve characteristics is also unknown.

B. Euroamerican Settlement

The earliest recorded explorations of the area were in 1825 and continued through the 1840s. Intensive settlement by Euroamerican peoples began during the 1860s. As Indian-White relations flared, the United States Government established the Fort Klamath Indian Agency at Fort Klamath in 1863.

In order to supply Fort Klamath with personnel and material, a wagon road beginning in Jacksonville was constructed through what is now LSR R0227. This road was known by two names: Rancheria Trail; and Drew's Road, named for Major C.S. Drew, who oversaw its construction. The road traversed the Fourmile Creek drainage until reaching the current community of Rocky Point, where it turned north and continued to Fort Klamath. A portion of this wagon road

is currently listed on the National Register of Historic Places. In 1865, this road was replaced by the Union Creek Road, which passes through LSR R0229, and followed the same path as current Highway 62. At about this same time, a wagon road connecting Ashland with Drew's Road was constructed (Thompson et al., 1979). Segments of this road can still be found in the southern portion of LSR R0227. Except for these road construction activities, little activity took place in the OECP LSR's until the early 1900s.

C. Forest Service Management

The OECP LSR's were originally part of the Cascade Forest Reserve. Emphasis of early Forest Service activities was on fire protection and timber stand inventories. In order to implement these goals, an extensive network of seasonally occupied Ranger Stations (or Guard Stations) and mountain top lookouts, connected by trails and telephone lines, was constructed throughout the Forests. Within the LSR's, several Ranger Stations were built, including those at Sevenmile Creek, Cherry Creek, Clover Creek, Lake of the Woods, and Fourmile Lake. Lookouts were established on various peaks, including Buck Mountain, within LSR R0227.

A timber sale program was in full progress by 1909, a year after an Executive Order established the Crater National Forest from the Cascade Reserve. A portion of the present Klamath and Siskiyou National Forests, most of the Rogue River National Forest, and the Klamath Ranger District of the Winema National Forest were included in the Crater National Forest boundaries (USDA, 1979).

In 1909, the Utter and Burns Company of Fort Klamath purchased 1.5 mmbf of timber from the Crater National Forest and built a mill at Annie Creek (within LSR R0229) to process the lumber. It is likely that portions of this sale were within that LSR.

In 1910, the Pelican Bay Logging Company purchased timber from the Crater National Forest and began constructing shortline railroads as a means to transport the lumber from the forest to the shores of Upper Klamath Lake, where logs were then rafted across to mills at Algoma and Klamath Falls. With the purchase of the Fourmile Sale (situated on the south flank of Pelican Butte in the Fourmile Creek Drainage), the Pelican Bay Lumber Company continued its railroad operations. Altogether, some 22 miles of railroad grade were built within LSR R0227, along with various administrative and working camps situated adjacent to the railroads (Thompson, 1994).

Also in 1910, the Fish Lake Water Company applied for a permit to construct a dam on the outlet of Fourmile Lake. Water from the lake and its tributaries was diverted from Fourmile Creek to the west side of the Cascades through the "Cascade Canal", eventually being used for irrigation in the Rogue Valley. This dam and canal system is still in use today, affecting flows in Fourmile Creek within LSR R0227. Portions of the canal are located inside the LSR boundaries.

A "Yellow Pine Bark Beetle Control Project" was started in 1922 after a billion board feet of timber had been killed in Southern Oregon and Northern California between 1911 and 1920. Because most of the area was still inaccessible, very little of the dead timber was salvaged. (USDA, 1979).

The Crater National Forest's first recorded timber management plan was written in 1928. On July 9, 1932, the present day Klamath Ranger District was assigned to the Rogue River National Forest by Presidential Order. The Rogue River National Forest had its first timber management plan approved in 1942.

Passage of the O&C Exchange Act of 1954 directed the Forest Service and Bureau of Land Management to exchange O&C and National Forest System lands. The exchange was intended to eliminate lands of intermingled jurisdiction and was completed in June 1956. Portions of LSR R0227 and R0228 include O&C lands.

The termination of the Klamath Indian Reservation and the sale of some of the reservation to the U.S. Government resulted in the formation of the Winema National Forest in 1961. The Rogue River's Klamath Ranger District was transferred to the newly-formed Winema National Forest.

Two major natural events had an impact on the OECP LSR's in the 1960's. The Columbus Day Storm of 1962 uprooted approximately ten million board feet of timber. The blown down timber was salvaged over a large area around Lake of the Woods. The Christmas Flood of 1964 scoured stream drainages, ripped up riparian vegetation, initiated landslides, and damaged transportation systems and developed recreation areas.

In 1961, the Klamath Basin Working Circle was established, which encompassed the entire Fremont National Forest and that portion of the Winema National Forest outside of the former Klamath Indian Lands. The Working Circle was a geographic division of forests created for administrative or marketing purposes. The first Timber Management Plan for the Klamath Basin Working Circle was adopted in 1964, and was the guiding document through 1977 (USDA, 1978).

In the 1970's, two planning efforts were begun that would guide the Klamath Ranger District. The first was the Timber Resource Plan for the Klamath Basin Working Circle. The purpose of this document was to update the 1964 plan of land suitability for timber production and to set annual program harvest levels. The second was the McLoughlin Klamath Planning Unit plan, which included the Klamath Ranger District of the Winema National Forest, along with the entire Rogue River National Forest. The purpose of this document was to assign management allocations (which included spotted owl habitat) and recommend potential wilderness areas (Map B). The Timber Resource Plan for the Klamath Basin Working Circle was adopted in 1978. The McLoughlin Klamath Planning Unit was adopted in 1979. From 1979 through 1990, both of these documents were used to manage the Klamath Ranger District.

In 1990, the Winema National Forest Land and Resource Management Plan was adopted (USDA, 1990). This plan superseded the Land Use Plan for the McLoughlin Klamath Planning Unit and the Timber Resource Plan for the Klamath Basin Working Circle. The Winema Forest Plan allocated a total allowable sale quantity of 44.6 million board feet to the Klamath Ranger District. Map C-1 and C-2 show the management areas designated by the Winema Forest Plan. Likewise, management areas designated by the Rogue River National Forest Land and Resource Management Plan of 1990 are shown in Map C-3.

In June 1990, the U.S. Fish and Wildlife Service listed the northern spotted owl as threatened throughout its range. In the fall of 1991, the Forest Service was challenged in Federal District Court by the Seattle Audubon Society for failure to formally adopt a credible conservation strategy that would comply, simultaneously, with the requirements of the Endangered Species Act, National Forest Management Act, and National Environmental Policy Act. On May 23, 1991, Judge Dwyer ruled against the Forest Service and issued an injunction against further timber sales in spotted owl habitat on National Forests, pending Forest Service adoption of a spotted owl habitat management plan following the process described in the National Environmental Policy Act (USDA, 1993). The injunction against timber sales in spotted owl habitat was lifted on June 6, 1994, after the adoption of the ROD.

D. Timber Harvest Summary

With the number of National Forests to which the Klamath Ranger District was once assigned, it is difficult to track early timber harvest in the OECP LSR's. The Pelican Bay Logging Company purchase of the Fourmile Sale in 1910 was probably the first large timber harvest in the OECP LSR's. No timber sales were recorded in the LSR's during the 1920s and 1930s. In 1948, 742 thousand board feet were sold to Modoc Lumber Company in T33S, R6E, at the edge of LSR R0229. In 1949, an additional 1,697 thousand board feet were sold to Modoc Lumber in the same general location. In 1959, two timber sales labeled partial cuts, totaling less than 400 acres, were sold inside LSR R0229.

Although extensive timber harvesting occurred in the Klamath Falls area prior to the 1940's, most of the OECP LSR's had only minor entries, due to limited access. By the mid 1960's, the transportation system was well established, and over sixty percent of the LSR's were cut. Timber harvesting consisted primarily of broad selective harvesting and salvage from the Columbus Day Storm of 1962.

Timber harvests from 1970 to the present entered an additional 15% of the OECP LSR's, but the majority of harvesting consisted of second and third entries in previously harvested areas. In the 1970's, widespread harvest of large white fir and the use of regeneration cuts occurred. In the 1980's, industry began utilizing small diameter white fir, while still taking large trees to make the sales economically feasible.

Since 1995, four timber sales have been offered which include units within the OECP LSR's in the Sevenmile, Cherry, and Rock Creek watersheds: the Nannie, Giddyup, Klamath, and Helirock Timber Sales. Timber harvest is being used in these areas to reduce risk of insect and disease mortality and lower potential for a large-scale fire. Treatment methods comply with guidelines detailed in the interim assessment. These sales will affect approximately 1% of the OECP LSR's. Additional treatments in the eastern portion of LSR R0227 are currently being proposed in the Lost and Fourmile Creek watersheds for 1997 and 1998.

E. Grazing Summary

Prior to 1903, unregulated grazing by both cattle and sheep occurred throughout the OECP LSR's. In 1903, permits were issued for sheep grazing. Grazing allotments were first established in 1938 and were later expanded to cover 80% of the LSR's. Over the years, allotments have been combined or discontinued.

Map D shows active grazing allotments within the LSR's, which currently cover approximately 10% of the area.

F. Recreation Summary

1. Lake of the Woods

Lake of the Woods became a popular recreation site early in the 1900s. By the early 1930's, about 20 recreation residences existed at the lake. Also in that decade, the lodge was built, and the Civilian Conservation Corps built what is now the Lake of the Woods Visitor Center and constructed a campground at Rainbow Bay. A Boy Scout camp, primitive in the 30's, was improved in the late 1950's. Currently, there are two developed campgrounds, three organizational camps, two day-use areas, one lodge/resort, one administrative site, and 217 recreational residences surrounding the lake. Located in LSR R0227 (Map E), Lake of the Woods is the most widely used recreational area on the Winema National Forest. In 1996, 223,474 recreation visitor days were reported (Moser, 1997).

2. Fourmile Lake Campground/Rye Spur Quarry

The Fourmile Lake Campground is located adjacent to Sky Lakes Wilderness at the edge of LSR R0227. This campground is less highly developed than the campgrounds at Lake of the Woods and includes only 25 sites. The Twin Ponds and Badger Lake wilderness trails can be accessed from the Fourmile Lake Campground. This area is popular with horseback riders. The Rye Spur Quarry is being developed into a dispersed site for large equestrian groups. New trails will be constructed to tie the Rye Spur site into the existing trail system and the Fourmile Lake area.

3. Trails and Trailheads

Most trails in the OECP LSR's are associated with the Lake of the Woods area. A social trail circumnavigates the shoreline of Lake of the Woods. A family bicycle trail makes a one-mile loop through the forest on the east side of the lake. The High Lakes Trail, completed in 1996, roughly parallels Highway 140 from Great Meadow Snowpark to Fish Lake. This is a multi-season, multi-use trail. The Brown Mountain Trail begins on the west side of Lake of the Woods, traversing southwest around the base of the mountain. The Rye Spur Trail heads north from Highway 140 to Fourmile Lake.

Approximately 176 miles of winter trails are located in the OECP LSRs. Great Meadow Snowpark is the most popular snowpark in southern Oregon. In 1996, 18,654 recreation visitor days were reported (Moser 1997). However, an estimated 64,000 vehicles make rest stops at the snowpark annually. The flat meadow is ideal for beginning snowmobilers and skiers, and is used annually by local snowmobile clubs for charity events. The Snowpark is also the trailhead for snowmobile and ski trails heading north, south, and west, including the border-to-border snowmobile trail, which traverses north/south from the California border to the Washington border.

The Mt. McLoughlin, Fourmile Lake, Clover Creek, Mt. Lakes, Cherry Creek, and Sevenmile wilderness Trailheads are located in the OECP LSR's. The Clover Creek and Sevenmile Trailheads offer dispersed camping.

4. Pelican Butte Semiprimitive Recreation Area

The Pelican Butte Semiprimitive Recreation Area is located in a large inventoried roadless area which includes the summit and slopes of Pelican Butte. Approximately 20% of the lowest elevations of this management area, on the north and east slopes of Pelican Butte, overlap with LSR R0227. Currently, dispersed recreation use includes snowmobiling, cross-country skiing, hiking, and sight-seeing.

The Winema Forest Plan designated a significant portion of Pelican Butte to semiprimitive recreation management with the option for future development of a ski area. In May of 1990, an Environmental Impact Statement (EIS) was initiated to evaluate a proposal by the City of Klamath Falls to construct a ski area on Pelican Butte. The effort was abandoned in July of 1991 because of potential effects on bald eagles and uncertainties concerning management direction for northern spotted owl habitat.

Following signing of the ROD and significant state-wide recovery of bald eagle populations, a new ski area proposal was initiated in 1994 by the Pelican Butte Corporation. In September 1996, the Forest began an EIS process to assess potential impacts of the development proposal. Initial assessments included in the conceptual master plan show potential for 2 miles of road construction and 160 acres of ski trail development within LSR R0227. Approximately 70 acres of existing spotted owl NRF (nesting, roosting, and foraging habitat) would be impacted.

5. Brown Mountain Semiprimitive Recreation Area

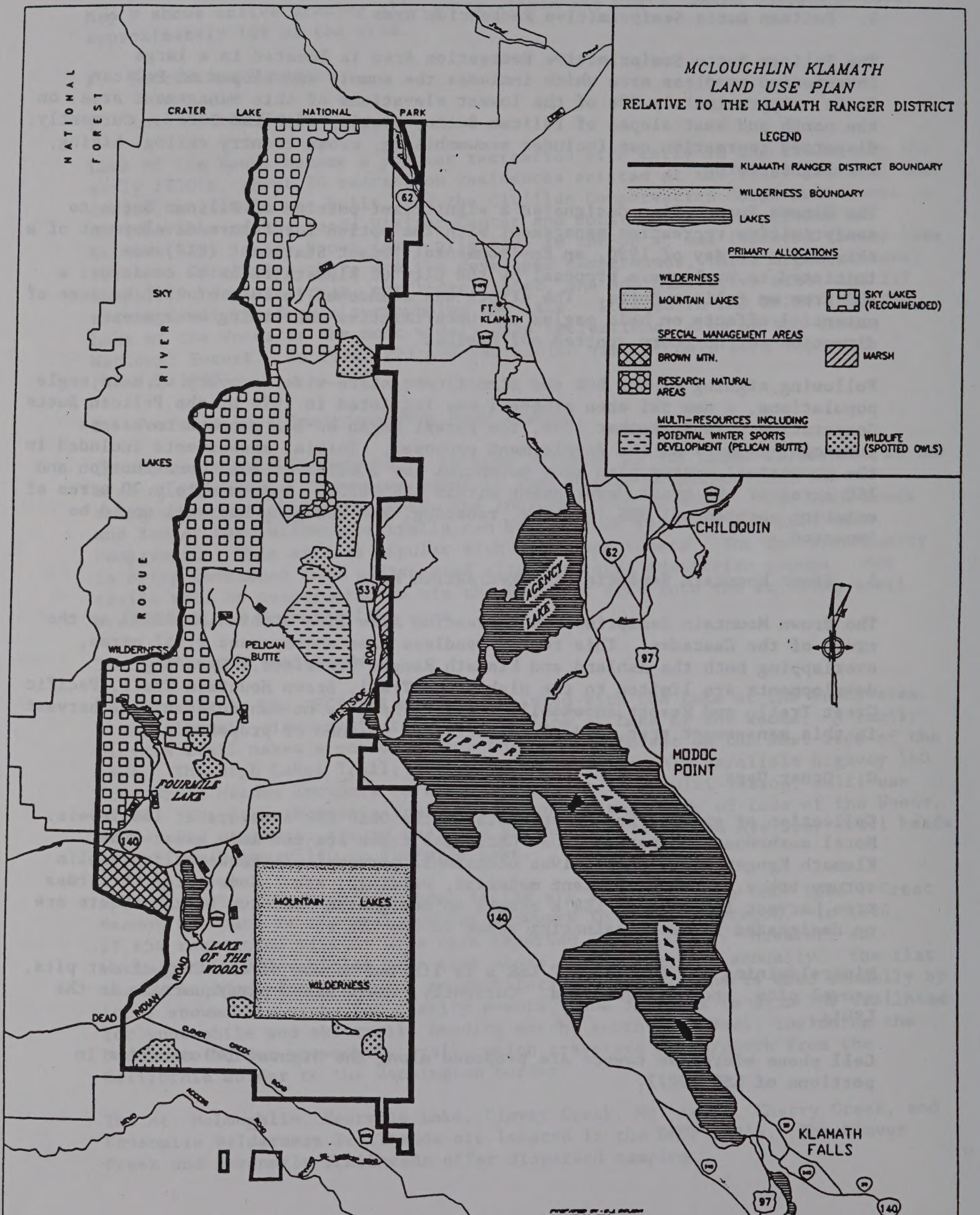
The Brown Mountain Semiprimitive Recreation Area lies within LSR R0227 at the crest of the Cascades. This rugged roadless area encompasses 9,137 acres, overlapping both the Ashland and Klamath Ranger Districts. Existing developments are limited to the High Lakes Trail, Brown Mountain Trail, Pacific Crest Trail, and Resort snowmobile trail. There is no scheduled timber harvest in this management area, and no projects are planned or proposed.

G. Other Uses

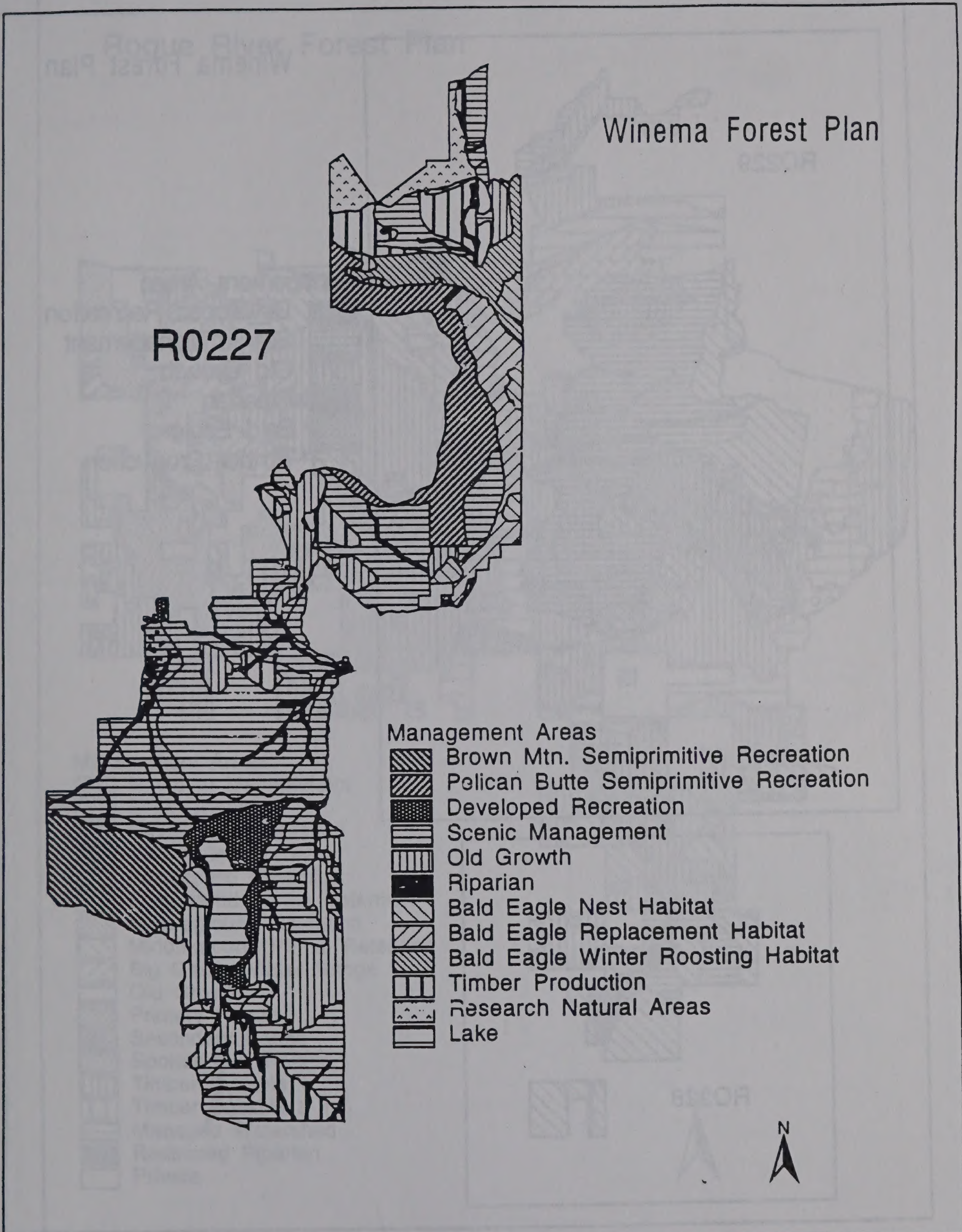
Collection of special forest products in the OECP LSR's occurs at low levels. Morel mushrooms and personal use Christmas trees are the main uses. The Klamath Ranger District receives occasional personal use requests for violin spruce trees, ornamental plant material, wildings, etc. Commercial Christmas tree harvest in the OECP LSR's occurs on designated road cut banks. There are no designated firewood gathering areas in the LSR's.

Mineral/mining use in the OECP LSR's is limited to use of existing cinder pits, gravel pits, and rock quarries. Currently, there are 4 pits/quarries in the LSR's.

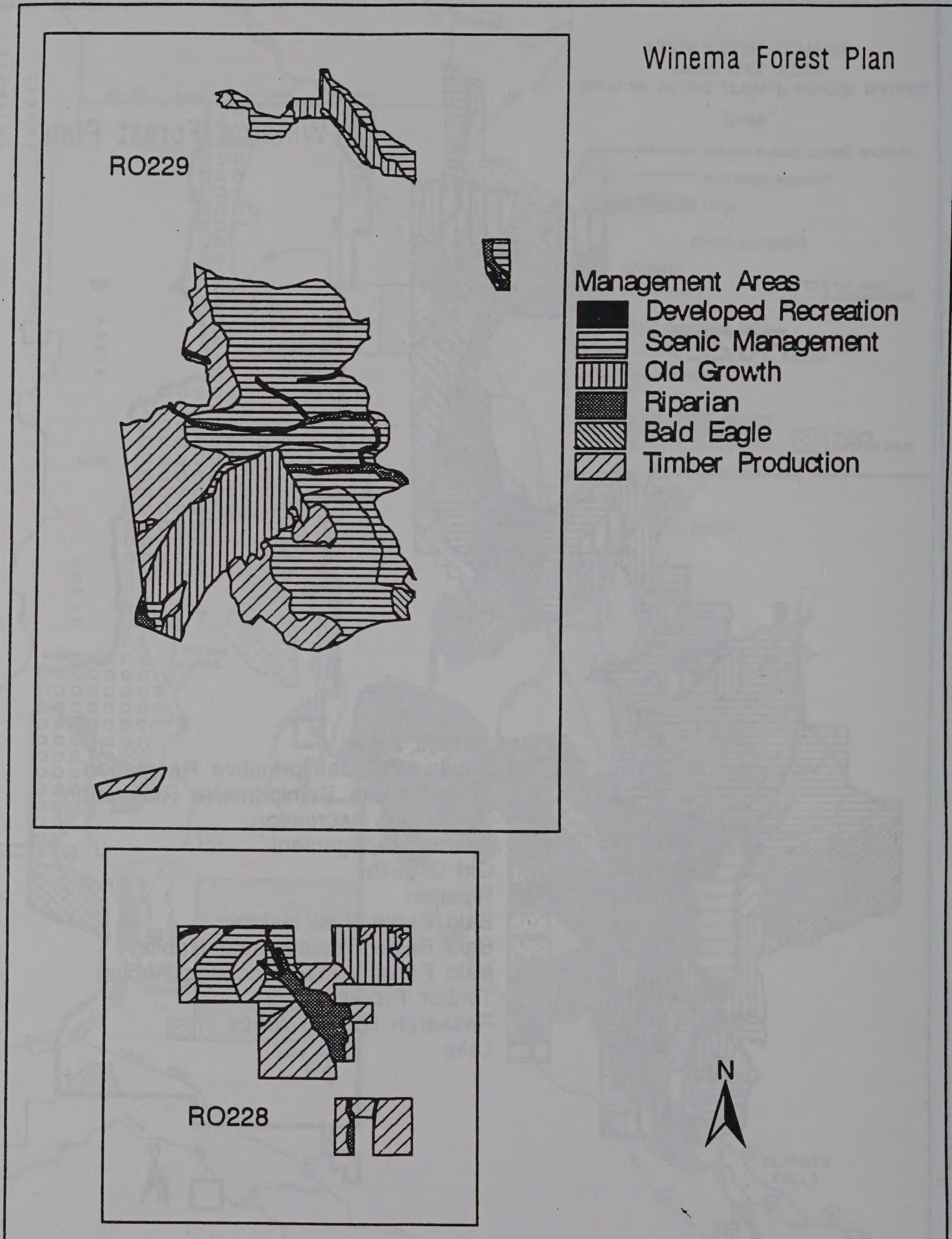
Cell phone microwave towers are proposed along the Highway 140 corridor in portions of LSR R0227.



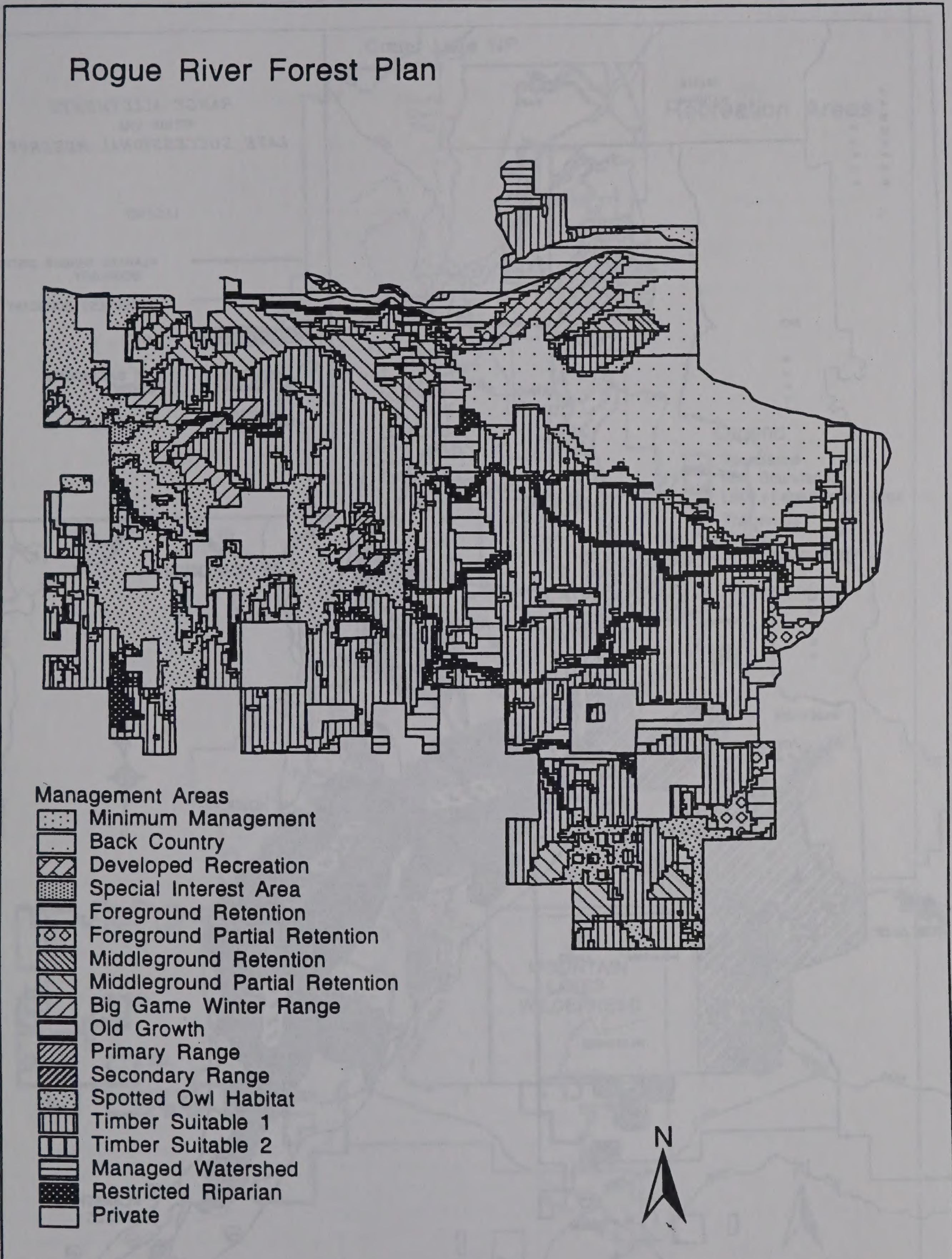
MAP B. MCLOUGHLIN KLAMATH LAND USE PLAN RELATIVE TO THE KLAMATH RANGER DISTRICT.



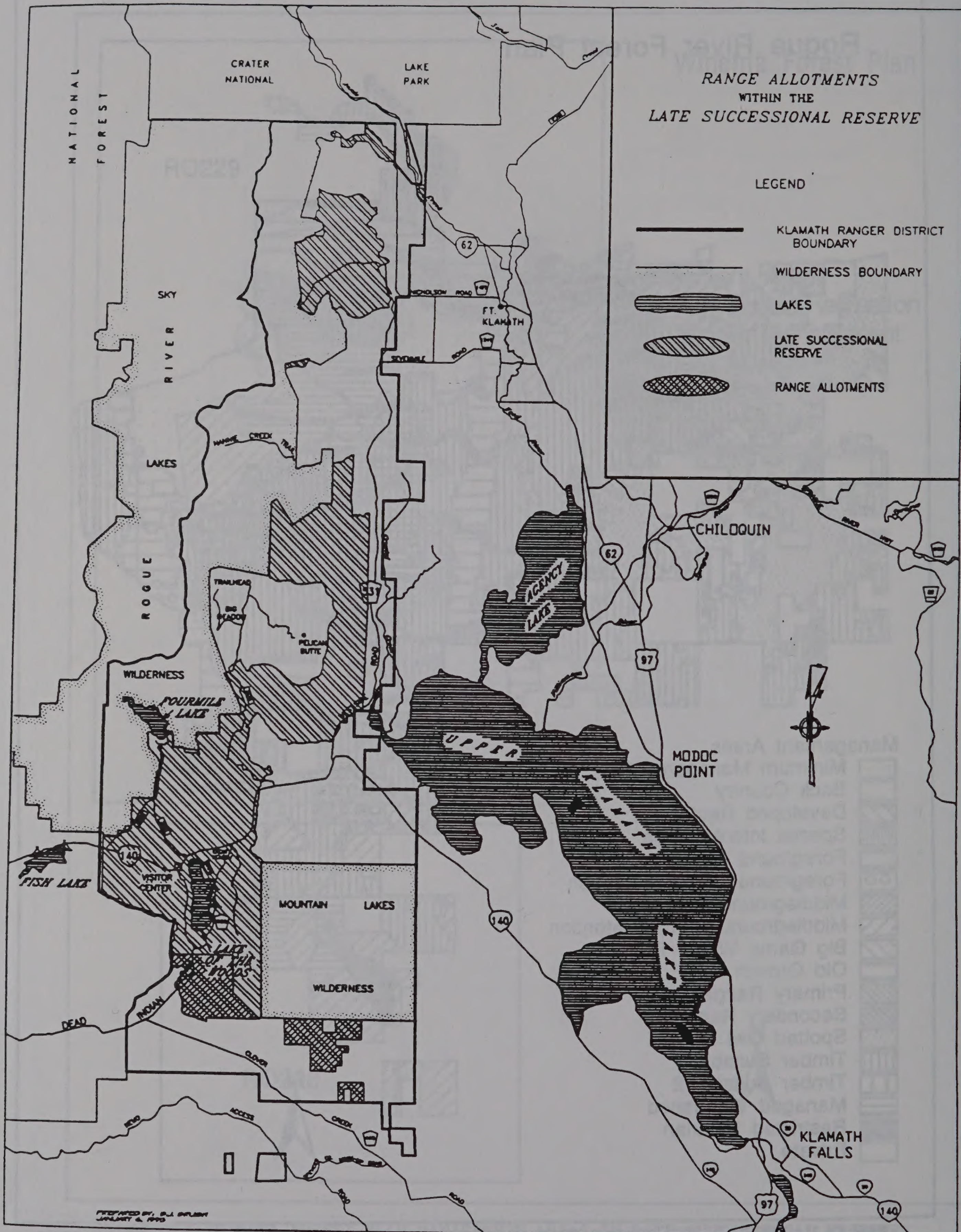
MAP C-1. WINEMA FOREST PLAN MANAGEMENT AREAS IN LATE SUCCESSIONAL RESERVE R0227.



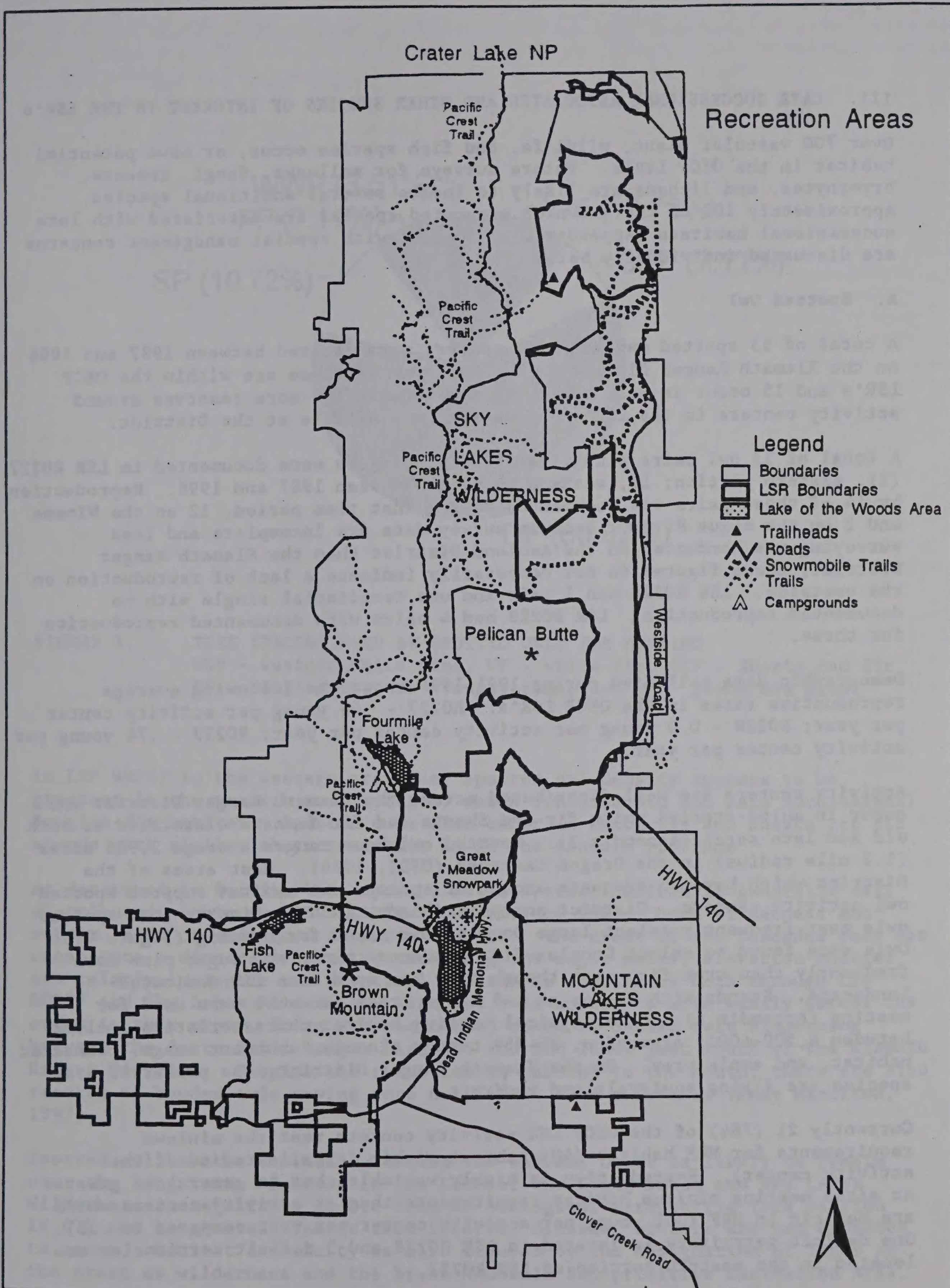
MAP C-2. WINEMA FOREST PLAN MANAGEMENT AREAS IN LATE SUCCESSIONAL RESERVES RO228 AND RO229.



MAP C-3. ROGUE RIVER FOREST PLAN MANAGEMENT AREAS IN LATE SUCCESSIONAL RESERVE R0227.



MAP D. RANGE ALLOTMENTS WITHIN THE OECP LSR'S.



MAP E. LOCATION OF MAJOR RECREATION SITES AND TRAILS IN THE OECP LSR'S.

III. LATE SUCCESSIONAL ASSOCIATED AND OTHER SPECIES OF INTEREST IN THE LSR's

Over 700 vascular plant, wildlife, and fish species occur, or have potential habitat in the OECP LSR's. Future surveys for mollusks, fungi, insects, bryophytes, and lichens are likely to locate several additional species. Approximately 100 of the known or suspected species are associated with late successional habitats (Appendix C). Species with special management concerns are discussed individually below.

A. Spotted Owl

A total of 53 spotted owl activity centers were located between 1987 and 1996 on the Klamath Ranger District. Twenty-seven of these are within the OECP LSR's and 15 occur in wilderness. A map showing 100-acre reserves around activity centers in the LSR's and matrix is available at the District.

A total of 33 owl pairs plus 5 territorial singles were documented in LSR R0227 (21, eastern portion; 17, western portion) between 1987 and 1996. Reproduction by 14 of those pairs was documented during that time period, 12 on the Winema and 2 on the Rogue River. Because survey data are incomplete and less surveying was conducted on the Ashland District than the Klamath Ranger District, these figures do not necessarily indicate a lack of reproduction on the westside. LSR R0228 had 1 pair and one territorial single with no documented reproduction. LSR R0229 had 4 pairs with documented reproduction for three.

Demographic data collected during 1991-1996 shows the following average reproductive rates in the OECP LSR's: R0227 - .46 young per activity center per year; R0228 - 0.0 young per activity center per year; R0229 - .74 young per activity center per year.

Activity centers are well distributed across the Klamath Ranger District and occur in multi-storied white fir and Shasta red fir forests classified as both mid and late seral (Appendix B). Spotted owl home ranges average 2,955 acres (1.2 mile radius) in the Oregon Cascades (USDI, 1994). Most areas of the District which have an adequate amount of spotted owl habitat support spotted owl activity centers. District analysis (Hardy, 1994) indicates that spotted owls most frequently select large Douglas-fir trees for nesting (Figure 1.). Owls were found to select Douglas-fir, ponderosa pine, and sugar pine more frequently than true fir, even though they are in a true fir dominated landscape. Stands with as few as 1-5 large trees per acre were used for nesting (Appendix A). Other typical nesting habitat characteristics include between 4,500-6000' elevation, 56-85% canopy closure, abundant snags, connected habitat, and ample prey. On the Klamath Ranger District, the preferred prey species are flying squirrels and woodrats.

Currently 21 (78%) of the OECP LSR activity centers meet the minimum requirements for NRF habitat (40% habitat within 1.2 mile radius of the activity center). Reproduction is highly variable, but in general is greater at sites meeting minimum habitat requirements than at activity centers which are deficit in NRF (.51 young per activity center per year compared to .38). One deficit terrritory is located in LSR R0228 and 5 deficit territories are located in the eastern portion of LSR R0227.

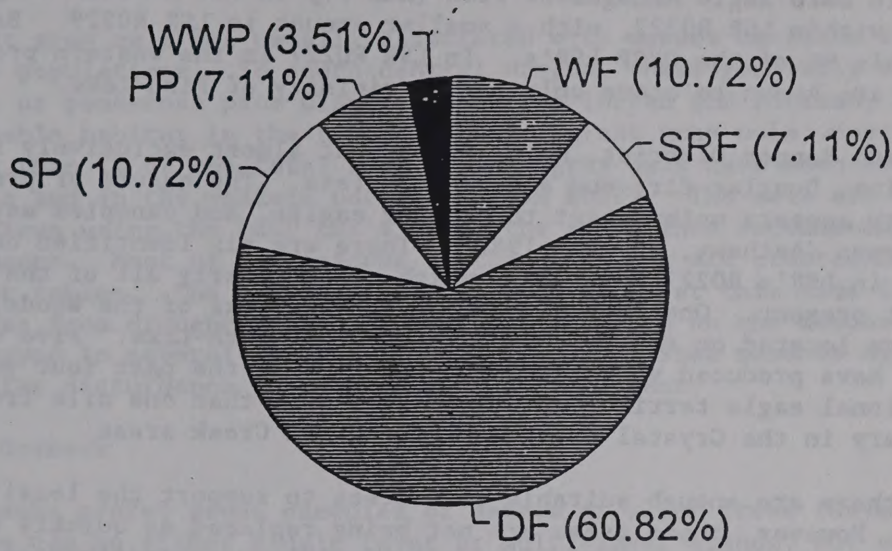


FIGURE 1. TREE SPECIES USED BY SPOTTED OWLS FOR NESTING. WWP - western white pine, WF - white fir, SRF - Shasta red fir, DF - Douglas-fir, SP - sugar pine, and PP - ponderosa pine.

In LSR R0227 in the western province, spotted owl density appears to be greatest in the western-most portion, which contains mid and late successional Douglas-fir habitat. Spotted owls also occur in white fir and Shasta red fir stands with similar characteristics as in the eastern province.

As described in Section VII, spotted owl dispersal habitat is generally well distributed within the OECP LSR's. Outside the LSR's, both wilderness and matrix lands provide good dispersal routes. The crest of the Cascades does not constitute a dispersal barrier; excluding the major peaks, elevation changes are relatively gentle and dispersal habitat is continuous both through LSR R0227 and Sky Lakes Wilderness. Spotted owls appear to move easily across the crest in this area. There are documented cases of banded owls dispersing between the Butte Falls Ranger District and BLM lands just south of the Klamath Ranger District. Despite the reduction in habitat to the south, there are also records of banded owls moving into California from this area (Andy Hamilton, 1997).

Spotted owl habitat continuity across the Cascade Crest is likely to remain over the long term. Habitat in the Lake of the Woods Basin and Sky Lakes Wilderness is relatively stable from an ecological perspective (See Section IV-C.) and large scale losses from insects, disease, or fire are not expected to occur. Habitat continuity is also insured by the designation of lands at the crest as wilderness and the Brown Mountain Semiprimitive Recreation Area.

B. Bald Eagle

Bald eagles are primarily associated with Upper Klamath Lake and Lake of the Woods. They use some of the stream systems and smaller lakes incidentally for foraging. Approximately 40% of the area designated as eagle habitat by the Klamath Basin Bald Eagle Management Plan (Map F.) on the Klamath Ranger District is within LSR R0227, with a smaller amount in LSR R0229. Bald eagle habitat totals 9% of the OECP LSR's. In LSR R0227 in the western province, bald eagles are known to occur only in the vicinity of Fish Lake.

On the Klamath Ranger District, bald eagles nest almost exclusively in live ponderosa pine, Douglas-fir, and sugar pine trees. The nature or presence of an understory appears unimportant to nesting eagles, and canopies may be relatively open (Anthony, et al., 1982). There are six identified nest territories in LSR's R0227 and R0229, which occupy nearly all of the potential nest habitat present. One nest is associated with Lake of the Woods; the remainder are located on the west side of Upper Klamath Lake. Five of these territories have produced young at least once during the past four years. Three additional eagle territories are located less than one mile from the LSR R0227 boundary in the Crystal Creek and Recreation Creek areas.

Currently, there are enough suitable nest trees to support the local bald eagle population. However, these trees are not being replaced as quickly as they die. By managing existing nest trees to last as long as possible and encouraging growth of replacement trees through silvicultural treatments, we can best meet bald eagle nest site needs in the future.

A bald eagle winter roost is located in the Rock Creek drainage on the east side of the Klamath Ranger District. Most of this winter roost (84%) is within LSR R0227. This roost provides habitat for up to 100 eagles during peak use periods. The peak use is generally of short duration, and timing of use varies from year to year. The portion of the roost that is used depends on weather conditions. The eagles tend to roost in more open stands close to foraging areas during mild weather. During harsh weather, the eagles fly further from foraging areas to roost in the most dense stands available. When Upper Klamath Lake freezes over, most of the waterfowl leave to find open water, and the eagles follow them. However, some of the local nesting eagle pairs remain in their territories through the winter (Hardy, 1994).

Winter roost habitat requirements for bald eagles are different than nest habitat. They are located in sheltered stands near a good food source. The stands have high canopy closures which provide thermal protection during cold periods. The preferred roost tree species are Douglas-fir, ponderosa pine, and sugar pine, the largest and tallest trees available (Dellasala, 1987). Treatment of roost stands to reduce mortality of these trees should focus on thinning white fir. This treatment could lower suitability for roosting eagles for up to 20 years, due to opening of the canopy and reduction of thermal cover. Initially, this treatment should not be applied to the primary stands used by eagles for roosting. A minimum of 50% of the winter roost should be maintained in a condition suitable for roosting bald eagles at all times.

Most of the foraging areas for bald eagles are in lake and wetland habitats outside of LSR boundaries. Loss of foraging areas around Upper Klamath Lake and reduction of prey species is a concern. Records indicate that waterfowl,

one of the primary prey species groups, are less than half as plentiful as they were near the turn of the century (Hainline, 1992). Also, the open water and marsh area has been reduced by agriculture. If this trend continues, the maximum number of eagles that can be supported will decline.

C. Great Gray Owl

Great gray owls are usually associated with meadow habitats which support good vole populations. In south-central Oregon, these generally occur in lodgepole pine or ponderosa pine plant communities (Bryan and Forsman, 1987). There is suitable habitat in the three LSR's for great gray owls; however, it makes up less than 1% of the total area. Great gray owls have been observed in the OECP LSR's and in the western portion of LSR R0227. The owls are expected to continue using the OECP LSR's under the guidelines recommended in this document. Most of the meadows in the OECP area are created/maintained by high water tables. The biggest risk to these sites at this time is lowered water tables from drought, allowing trees to encroach on the meadows. This has been observed in several meadows in recent years. Some meadows may need fire or similar disturbance to control tree encroachment.

D. Goshawk

Goshawks prefer dense canopies of mature or older trees (Reynolds, 1989). These can be either single layer or multi-layer stands, but should be open enough to permit flying underneath the canopy. Goshawks select north slopes near water more often than other habitats. Habitat for northern goshawks is widespread throughout LSR's R0227, R0228, and R0229. The primary prey species for goshawks are small to medium sized birds and rodents. Short snags, down logs, or stumps are used by goshawks for plucking posts. There are seven known goshawk nests within the OECP LSR's. Only a portion of the Cherry, Sevenmile, Spencer, and Clover Creek drainages, totaling about 25% of the OECP LSR's, have been surveyed for goshawks. None of those surveys met current protocol.

E. Pine Marten

Pine martens prefer mature or older forests (including lodgeple pine), with large numbers of snags and coarse woody debris (Jones and Raphael, 1990). Recent studies have identified large slash piles as being important to martens (Raphael, 1994). Trees with branches that reach to the ground provide access through the snow during the winter. Dens are located in trees or underground. Martens often have multiple dens which they move between during the rearing season. They feed on rodents and opportunistically on other small mammals and birds. Winter food sources are critical to marten survival as they carry very little fat reserves on their bodies. Martens are thought to be widespread throughout all three LSR's, but few surveys for them have been conducted.

F. Fisher

Fishers prefer dense stands with 70-80% canopy closure. They den in cavities in the ground, under logs, or in large live trees over 46" diameter (Buck et al., 1983). Male fishers have a very large home range of six square miles or more. Several female home ranges generally overlap the male home range in areas with good population densities. Fishers have a low reproductive rate; so populations do not recover quickly from a loss. They feed on porcupines,

squirrels, and other rodents. Fishers were transplanted in or near LSR R0227 in the Buck Lake area in 1961 (Ingram, 1973).

Three fishers were documented on the Klamath Ranger District in 1996. Two of those had previously been trapped on the Rogue River National Forest and fitted with radio transmitters. One of the fishers has stayed in the vicinity of LSR R0229 and the other has been using LSR R0227 (Way, 1995). These data indicate that fishers also freely move across the crest of the Cascades in this area.

G. Bats

Several species of bats occur in the Southern Oregon Cascades and are likely to be present in portions of the three LSR's. Surveys on the Winema National Forest have located silver-haired bats, long-eared myotis, long-legged myotis, Yuma myotis, and California myotis. Other species suspected of occurring in the OECP LSR's include fringed myotis and pallid bats. Bats are known to roost in caves, mines, and abandoned buildings; under bridges; and in the crevices or behind the bark of large snags and trees. Meadows, riparian areas, and open water provide important foraging areas for some species.

H. Bull Trout

Bull trout are adapted to cold water ecosystems and depend on cold water for much of their life history. Resident bull trout feed primarily on aquatic insects, but can become piscivorous if they grow large enough. Bull trout spawn in the fall, preferably at sites with spring groundwater infiltration. Embryos incubate over winter and fry emerge in April or May. Because of this long incubation period, eggs are susceptible to high or low winter flows and sedimentation of spawning gravels. Juveniles are bottom dwellers, primarily using substrate and woody debris for cover. The microhabitat most often associated with the adult fish is deep pools and large woody debris. Competition and hybridization with exotic fish species and restriction of interbasin migrations are two of the most critical elements affecting the viability and stability of populations in the Klamath Basin. Bull trout have been documented in Cherry Creek in the past, but currently are known to occur only in Threemile Creek outside the LSR's. The species is believed to have occurred historically in Rock and Sevenmile Creeks within LSR R0227 and R0229.

I. Lost River and Shortnose Suckers

Little is known about the habitat preferences of suckers. Most of the available information describes habitat utilization. Both are long-lived, omnivorous, lake-dwelling species that spawn in tributary springs or streams. Larval suckers quickly migrate from natal tributaries back to Upper Klamath Lake, where they are associated primarily with shallow shoreline areas providing vegetative cover. Juvenile suckers are also known to utilize this habitat. At the onset of warm water temperatures, algae blooms, and high pH, there is a redistribution of suckers to areas of the lake near stream or spring inflows, where more desirable water quality conditions are available. One such area is Pelican Bay, which is adjacent to LSR R0227. Reduction and degradation of lake and stream habitat in the Upper Klamath Basin is considered to be the most important factor in the decline of both species. Neither of the suckers is known to utilize stream habitat within the LSR's. However, proposed critical habitat (areas thought to provide critical habitat features essential

to the conservation of the Lost River and shortnose sucker) has been designated within LSR R0227. Overlap between LSR R0227 and proposed critical habitat occurs along Fourmile Creek (Map G).

J. Green-flowered Ginger

Green-flowered ginger (Asarum wagneri) is a long-lived perennial endemic to the Southern Oregon Cascades. It is listed as a sensitive species on the Regional Forester's Sensitive Species list. Green-flowered ginger occurs with a scattered-patchy distribution throughout much of LSR R0227, except for the northernmost areas and lower elevations. It also is found in portions of LSR R0228. The species generally grows in white fir, Shasta red fir, and lodgepole pine-dominated stands. It appears to prefer partially open canopies, either in early seral habitats, or in older stands with gaps and edges. Monitoring indicates plant density, growth, and reproduction are low in densely canopied forest. Intensive logging is also detrimental to the species; created openings, such as clearcuts and shelterwood cuts, generally contain only a few individuals located in protected microsites. Commercial or precommercial thinning may be needed in some areas of LSR R0227 to maintain the current level of suitable ginger habitat.

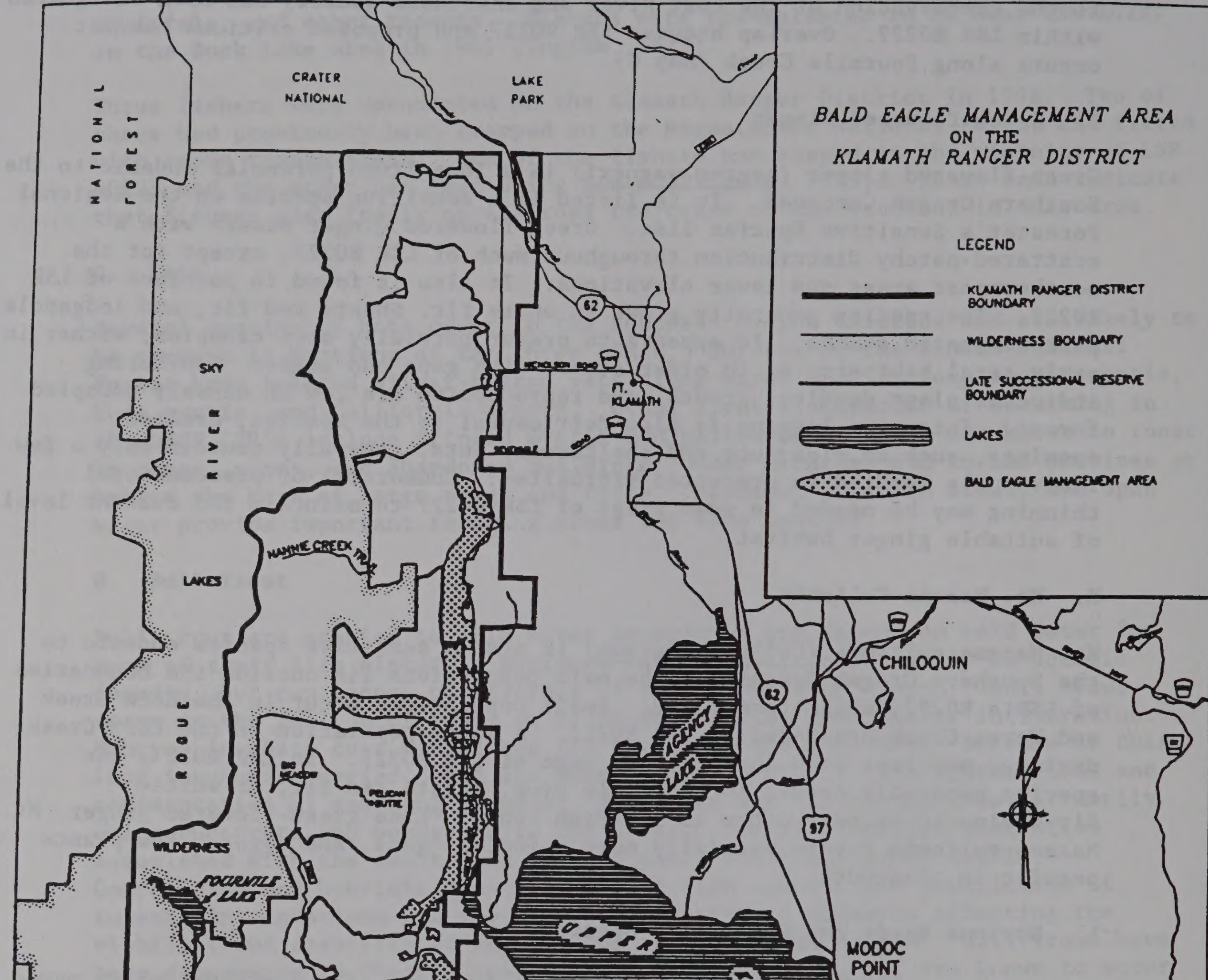
K. Mt. Mazama Collomia

Mt. Mazama collomia (Collomia mazama) is also a sensitive species endemic to the Southern Oregon Cascades. The main populations lie outside the boundaries of LSR's R0227, R0228, and R0229. Small populations occur in the Rock Creek and Horse Creek drainages of LSR R0227. A large population in the Lost Creek drainage overlaps with the northern edge of LSR R0227. In LSR R0227, the species generally occurs in lodgepole pine, Shasta red fir, or white fir-dominated stands, often in riparian zones. Like green-flowered ginger, Mt. Mazama collomia favors partially open canopies, gaps, and edges. Few plants persist in clearcuts.

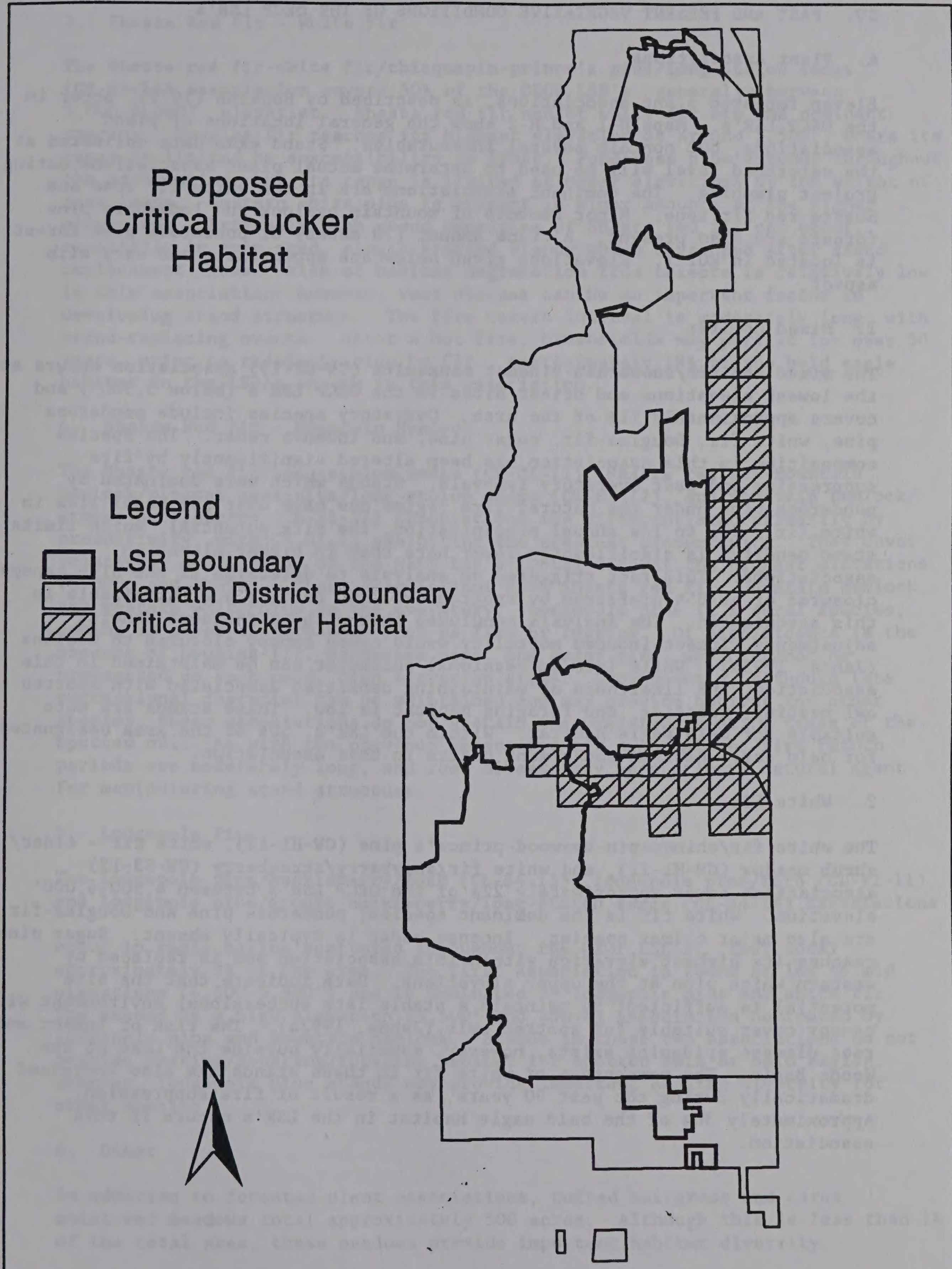
L. Noxious Weeds and Non-Native Species

In the three LSR's, noxious weed species occur primarily along the major paved roadways: Highway 140 and Dead Indian Memorial Road. In the OECP LSR's, noxious weeds also occur to a lesser extent along Forest Roads 3334, 3621, 3625, 3650, 3704, and 3850. Roadways provide open, disturbed habitat and routes for dispersal of weed seeds. Continual establishment of new sites occurs along the paved routes. The main species of concern are knapweeds, dalmation toadflax, and St. Johnswort. Currently, noxious weeds are not causing displacement of native vegetation in the OECP LSR's. Treatment of weeds is ongoing and addressed in the Winema National Forest Noxious Weed Environmental Assessment.

Several non-native species have spread throughout the LSR's to the point of becoming naturalized. Common non-natives include cheatgrass, Kentucky bluegrass, mullein, and bull thistle. Most non-native species occupy disturbed sites and are absent from coniferous forest. However, bluegrass, along with other pasture grasses, have been seeded in moist meadows, displacing native species. In the westernmost portions of LSR R0227 (e.g., South Fork Little Butte Creek Canyon), displacement of native vegetation by non-natives is occurring in oak woodlands, grasslands, and shrub communities.



MAP F. BALD EAGLE MANAGEMENT AREAS ON THE KLAMATH RANGER DISTRICT.



MAP G. PROPOSED CRITICAL HABITAT FOR THE LOST RIVER AND SHORTNOSED SUCKER.

IV. PAST AND PRESENT VEGETATIVE CONDITIONS OF THE OECP LSR's

A. Plant Associations

Eleven forested plant associations, as described by Hopkins (1979), occur in the OECP LSR's. Maps H-1 and H-2 show the general locations of plant associations, but contain several inaccuracies. Stand exam data collected at the watershed level will be used to determine actual plant associations during project planning. The dominant associations are in the white fir zone and Shasta red fir zone. Minor amounts of mountain hemlock and lodgepole pine forests are also present. A trace amount (20 acres) of ponderosa pine forest is located in R0227. Elevations given below are approximate and vary with aspect.

1. Mixed Conifer

The **mixed conifer/snowbrush-pinemat manzanita (CW-C2-15) association** occurs at the lowest elevations and driest sites in the OECP LSR's (below 5,500') and covers approximately 11% of the area. Overstory species include ponderosa pine, white fir, Douglas-fir, sugar pine, and incense cedar. The species composition in this association has been altered significantly by fire suppression and past overstory removals. Stands which were dominated by ponderosa pine under the natural fire regime now have over 85% basal area in white fir. Due to low annual precipitation, the site potential, which limits stand density, is significantly lower here than in higher elevation associations. This fact triggered an analysis to determine if the high canopy closures of 56-85% preferred by spotted owls for nesting are sustainable in this association. The analysis concluded that without frequent density adjustments, insect-induced mortality would cause canopy closures to decline (Jahns, 1993a). While late successional character can be maintained in this association, the likelihood of maintaining densities associated with spotted owl nesting, roosting, and foraging habitat is low. These stands are more suitable for bald eagle habitat. Within the LSR's, 50% of the area designated for bald eagle habitat management occurs in this association.

2. White Fir

The **white fir/chinquapin-boxwood-prince's pine (CW-H1-12), white fir - alder/shrub meadow (CW-M1-11), and white fir/snowberry/strawberry (CW-S3-12) associations** cover approximately 22% of the OECP LSR's between 4,500-6,000' elevation. White fir is the dominant species; ponderosa pine and Douglas-fir are also major climax species. Incense cedar is typically absent. Sugar pine reaches its highest elevation within this association and is replaced by western white pine at the upper elevations. Data indicate that the site potential is sufficient to maintain a stable late successional environment with canopy cover suitable for spotted owls (Jahns, 1993a). The risk of insect and root disease epidemics exists, however, especially outside the Lake of the Woods Basin. The percentage of white fir in these stands has also increased dramatically during the past 90 years, as a result of fire suppression. Approximately 30% of the bald eagle habitat in the LSR's occurs in this association.

3. Shasta Red Fir - White Fir

The Shasta red fir-white fir/chinquapin-prince's pine/long-stolon sedge (CR-S3-11) association covers 50% of the OECP LSR's, generally between 5,000-6,000' elevation. Shasta red fir and/or white fir are the dominant species. Douglas-fir reaches its highest elevation at around 5,500', where its range is limited by susceptibility to frost. Ponderosa pine extends throughout the association, but its range is limited at upper elevations by the weight of snow loads. Western white pine is present in minor amounts at the higher elevations. Extremely high stand densities of Shasta red fir can occur, especially in even-aged, single-storied stands which developed after stand replacement fires. Risk of habitat degradation from insects is relatively low in this association; however, root disease can be an important factor in developing stand structure. The fire return interval is moderately long, with stand-replacing events. After a hot fire, brushfields may persist for over 50 years, prior to recolonization by fir. Approximately 18% of the bald eagle habitat in the LSR's occurs in this association.

4. Shasta Red Fir - Mountain Hemlock.

The Shasta red fir/long-stolon sedge (CR-G1-11), Shasta red fir-mountain hemlock/pinemat manzanita/long-stolon sedge (CR-S1-12), and mountain hemlock/grouse huckleberry (CM-S1-11) associations are differentiated primarily by productivity, with CR-G1-11 exhibiting the greatest productivity. They cover relatively small areas of the OECP LSR's (total 11%) at the highest elevations (6,000' and above). These associations have Shasta red fir, mountain hemlock, and western white pine in the overstory. Lodgepole pine is a seral species, coming in after disturbances such as fire or logging. Of significance is the absence of Douglas-fir, ponderosa pine, and sugar pine, which cannot be propagated on such cold, high elevation sites. Consequently, although late successional character can be maintained and may provide habitat for other species, these associations do not sustain the preferred nesting trees of the spotted owl. As with the previous Shasta red fir association, fire return periods are moderately long, and root disease may be a primary natural agent for manipulating stand structure.

5. Lodgepole Pine

The lodgepole pine/huckleberry/forb (CL-S4-13), lodgepole pine/forb (CL-F1-11), and lodgepole pine/grouse huckleberry/long-stolon sedge (CL-S4-14) associations occur in small basins scattered throughout the OECP LSR's. They total approximately 3% of the area. The first association is found at low to mid elevations (4,500-5,500') and is dominated by lodgepole pine and white fir. The second is a high elevation (5,500' and above) association dominated by lodgepole pine and mountain hemlock. Stands in these two associations do not provide nesting/roosting/foraging habitat for spotted owls or bald eagles. However, lodgepole pine stands may provide important habitat diversity for other species.

6. Other

In addition to forested plant associations, tufted hairgrass and carex moist-wet meadows total approximately 500 acres. Although this is less than 1% of the total area, these meadows provide important habitat diversity.

Plant Associations	Percent of OECP LSR's
Mixed Conifer	11%
White Fir	22%
Shasta red fir - white fir	50%
Shasta red fir - mountain hemlock	11%
Lodgepole pine	3%
Meadow	<1%
Brush	<1%
Rock	2%
Rock with Scattered Conifers	<1%
Water	1%

FIGURE 2. PLANT ASSOCIATIONS IN THE OECP LSR'S.

B. Climate and Soils

The climate of the Oregon Eastern Cascades province is characterized by warm, dry summers and cool, wet winters. Frost can occur during the early part of the growing season at higher elevations and in recessional basins where cold air is trapped. Precipitation ranges from 25" at lower elevations near Upper Klamath Lake to 50" at the Cascade Crest. Most of the annual precipitation occurs as snowfall; however, spring rains often occur. During the late summer, lightning storms are common and are seldom associated with rain. These climatic parameters fundamentally influence the distribution and development of vegetation.

The soils of the province are primarily derived from weathered basalts and andesites dating from the formation of the Cascades. The effects of alpine glaciation are obvious in the drainages of the central part of the Klamath Ranger District. For example, Cherry Creek exhibits the classical U-shaped valley, with steep scoured sides, and terminates in an alluvial fan. Fourmile Creek flows through a flat where all of the fine material has been removed by meltwaters. These factors have left a landscape that has exceptionally rocky, though very productive, soils. The northern portion of the District is overlain with a deep cap of pumice from the Mt. Mazama blast 6,000 years ago. Productivity of the soils in this area is less than where residual soils are present (Carlson, 1979).

C. Lake of the Woods Basin

The Lake of the Woods Basin (Map I) is unique because the character of the vegetation is transitional between "eastside" and "westside" (that is, east and west of the Cascade Range) conditions. This area has higher precipitation and higher humidities during the growing season than the rest of the OECP LSR's. Douglas-fir is a common species in this area, and the shrub and forb components are typical of forests west of the Cascades. The incidence of fire historically has been less frequent in the Lake of the Woods Basin than in mid elevation areas elsewhere on the District. However, when fire events did occur, they tended to be large, stand-replacing events, similar to those occurring west of the Cascades. Insect and disease complexes that are at epidemic levels in other parts of the District have been naturally held to endemic levels in the Basin. Severe frosts during the growing season make this

area different from westside stands of similar structure and profoundly affect the distribution of frost-sensitive species, such as Douglas-fir.

D. Landscape Pattern

The forests of the Eastern Oregon High Cascades were historically less continuous than Douglas-fir forests on the west side of the Cascades. Eastside forests were broken up by the presence of cinder cones, lava flows, and persistent wetlands and lakes. The more frequent fire occurrences created open stands and brushfields. Fire-induced open stands tended to be concentrated at lower elevations and in subalpine areas. At mid elevations, there was a more continuous pattern of late successional habitat broken up by typically small (20-100 acre) brushfields and various-sized lava flows.

Management activities have altered the historical forest pattern. Fire suppression has allowed brushfields to succeed to forest and has reduced the rate of brushfield creation by stand-replacing fires. Analysis of fire data over the past 30 years indicates 98% of all fires on the District have been held to 9 acres or less. This means that fires now leave small "holes" in the existing vegetation, ranging from 1/4 to 9 acres in size. Timber harvest has created additional openings (typically 40-60 acres) and thinned stands independent of the elevation gradient. Consequently, in the drainages analyzed, late successional forest is now more fragmented. Although the landscape pattern is currently different from pre-management times, the difference is not nearly as great as the change that occurred on the west side of the Cascades during the same time period.

E. Late Successional Forest

1. Characteristics

Defining late seral character is an area of inquiry that is currently being hotly pursued. Bill Hopkins, USFS Area Ecologist, has developed a draft set of classification schemes for South Central Oregon which emphasize structural elements, relative abundance of biological legacies, and size of trees. Simultaneously, Fred Hall, USFS Regional Ecologist, is developing definitions that are regional in scope and key on species composition as a prime variable. Although the approaches diverge, there is a general understanding of what constitutes late successional character. The following are important parameters defining late successional character on the Klamath Ranger District (see also Appendix A for analysis of spotted owl nesting habitat):

1) Multiple canopy layers
2) Domination by late seral species
3) Presence of large trees greater than 20" in diameter
4) Relatively high canopy closures of 56-85% (may be lower in the mixed conifer CW-C2-15 plant association)
5) Relatively high decadence, as measured by abundance of snags, down logs, and deformed trees
6) Presence of canopy gaps
7) Retention of multi-species, including ponderosa pine, sugar pine, and Douglas-fir forest remnants

Moderate to high accumulations of lichens and bryophytes are not common outside of riparian areas in the OECP LSR's. These species are generally less diverse and occur in lower amounts in the eastern province than west of the Cascades, because of the drier climate.

2. Distribution in the OECP LSR's

Approximately 36% of the OECP LSR's currently consist of late successional forest (see Appendix B for the method used to determine late successional forest). Maps J-1 and J-2 and Figure 3 show the distribution of late successional habitat among the OECP LSR's.

Successional Stage	R0229	R0228	R0227 (east)
Late	27%	40%	36%
Mid	67%	51%	52%
Early	6%	9%	8%
Non-forest	<1%	<1%	4%

FIGURE 3. SUCCESSIONAL STAGES IN THE OECP LSR's.

3. Comparison of Late Successional Forest and NRF

Spotted owl NRF habitat is comprised of both late and mid successional stands and is more abundant in the OECP LSR's than late successional habitat. Stands which meet NRF criteria but are not considered to be late successional are generally lacking in a sufficient number of large-sized trees. As noted in Section III-A., spotted owl activity centers occur in stands with as few as 1-5 large trees per acre on the Klamath Ranger District. Except for high elevation mountain hemlock habitat, lodgepole pine basins, and low elevation pine-dominated stands with relatively open canopies, almost all late successional habitat meets the definition of NRF habitat.

LSR	NRF Habitat
R0227 (east)	49%
R0228	49%
R0229	45%

FIGURE 4. DISTRIBUTION OF NRF HABITAT AMONG THE OECP LSR'S.

Because NRF is the more inclusive habitat type and management of NRF habitat to maintain or promote development of late successional characteristics will result in development of late successional habitat over time, it is prudent to focus on management of NRF in this document. NRF habitat is also better defined and more accurately mapped on the Klamath Ranger District than late successional habitat. (See Map O in Section VIII.)

Map K shows areas not capable of developing NRF habitat and stands where NRF may develop but is not sustainable over the long term. Lands incapable of

developing NRF include mountain hemlock, lodgepole pine, and ponderosa pine forest types, rock, lakes, and natural meadows. Incapable lands total 13% of the OECP LSR's. Unsustainable lands occur at the lowest elevations, where site potential is insufficient to support high canopy closure over the long term. Approximately 11% of the OECP LSR's are unsustainable. Currently, 37% of the unsustainable lands meet NRF requirements, but are in an unstable condition.

F. History and Changes in Forest Vegetation

Fire suppression and timber harvest are the two management activities which have had the greatest effect on forest vegetation in the LSR's.

Fire suppression began in the early part of the century and greatly altered the natural disturbance regime. In the OECP LSR's, the fire regime in the white fir zone was characterized by frequent low intensity fires, with an average return period of 10-40 years. Within the Shasta red fir zone and Lake of the Woods Basin, both low intensity and stand-replacing fires occurred. The average return interval is estimated to have been 40-60 years (based on Agee, 1993). The frequency of lightning ignitions has probably not changed. However, since data collection began in the 1960s, 98% of fires on the Klamath Ranger District have been less than ten acres in size, due to suppression. Seral communities dominated by fire resistant species, such as ponderosa pine, sugar pine, and Douglas-fir, were maintained by the frequent fires. Without repeated burning, true fir species, which are susceptible to fire, colonized the understories of seral communities. Regeneration of seral species declined and stands converted to true fir dominance. Brushfields were also colonized by true fir.

Significant logging did not occur in most areas of the OECP LSR's until the 1950s and 1960s, at which time, large diameter ponderosa pine, sugar pine, and Douglas-fir were cut with partial overstory removals. Some harvests were designed to lessen risk of insect infestation. At lower elevations, mountain pine beetle infestations were beginning, promoted by the added stress of developing fir understories. Removal of Douglas-fir infected with dwarf mistletoe was a treatment at this time, as well. Reforestation activities were limited to brushfield conversion. During the 1970s, regeneration cuts were done, sometimes in multiple stages with shelterwood prescriptions. Reforestation efforts which emphasized reintroduction of shade intolerant tree species, such as ponderosa pine and Douglas-fir, met with varying success. During the 1980s, changes in the timber industry's ability to market small diameter true fir led to an emphasis on thinning of immature true fir stands. This sequence of logging events resulted in many stands being entered two to three times. Timber harvest coupled with fire suppression created a predominately young forest (dominated by true fir trees less than 100 years old), except in the Lake of the Woods Basin.

An analysis of vegetative changes from 1940 to 1988 in LSR R0229 and the northern portion of LSR R0227 was conducted using parameters such as tree size, number of canopy layers, and canopy closure. The sample was chosen because historical data for this area has been entered into GIS and an Oracle database. Current conditions in the sample appear to be representative of those throughout the LSR. Appendix B describes the data sources and definitions used.

Approximately 63% of the northern OECP LSR area was covered by late seral forests in 1940 (Figure 5.). Roughly 95% of the late seral stands were dominated by trees greater than 20" in diameter at that time. Only 5% of the late seral stands were dominated by small trees with large remnant trees in the overstory. By 1988, the amount of late successional forest had been reduced to 33% of the area. Many (68%) of the remaining late seral stands in this area are now dominated by small trees with large remnant trees comprising about 30% of the overstory canopy. Only 32% of the late seral stands in this area are currently dominated by trees greater than 20" in diameter. These changes demonstrate the effects of past overstory removals.

Figure 6. shows the changes in canopy closure which occurred from 1940 to 1988. In 1940, 59% of the northern LSR area had canopy closures of 56% or greater. By 1988, this figure had dropped to 49% of the area. This change was largely the result of timber harvest, which created low density stands with less than 40% canopy closure. In the white fir zone at lower elevations, there is evidence of stands filling in as a result of succession in the absence of fire. However, overall, timber harvest offset this effect.

G. Stand Dynamics

In addition to changes in structure and density, stand dynamics in the OECP LSR's have been altered as well. Computer simulations of the future forest reveal a high potential for the late successional character of existing stands to degrade over time. The seven attributes of late successional character are considered below.

1. Multiple Canopy Layers

Today, over 60% of the forest in the OECP LSR's has multiple canopy layers. Single-storied stands are generally plantations, stands that have been subjected to an overstory removal followed by precommercial thinning, or stands that have regenerated after fire. The multi-storied structure developed for two reasons. First, individual ponderosa pine, sugar pine, and Douglas-fir trees were left during past partial overstory removals. Second, fire suppression allowed development of multiple-sized, single cohort fir understories <100 years old. As these stands continue to develop at current high densities, the effects of middlestory suppression will eliminate lower canopy levels. Although true fir can persist in the understory for a long time, decades of living below a dense canopy causes suppression mortality. Forest Vegetation Simulator projections indicate that without middlestory mortality events, the understory will be shaded out and stands will become single storied in another 40-60 years (Jahns, 1993b)

2. Late Seral Species

Currently, forest in the OECP LSR's is dominated by late seral tree species. True fir percentages have increased from an estimated 40% of the stand basal area in pre-management times to 85% today. This trend toward a monoculture is expected to continue until disturbances, such as catastrophic fire, root disease, or landscape level insect attack, occur, allowing shade intolerant species (pines and Douglas-fir) to come back in.

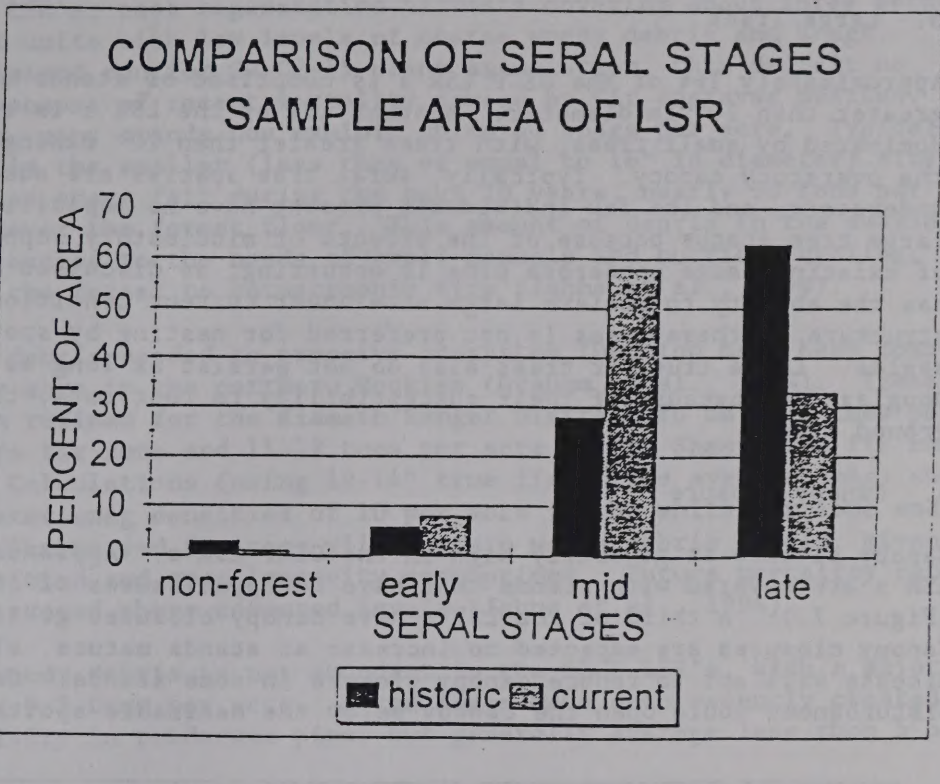


FIGURE 5. COMPARISON OF HISTORIC AND CURRENT SERAL STAGES IN A SAMPLE AREA OF THE OECP LSR'S.

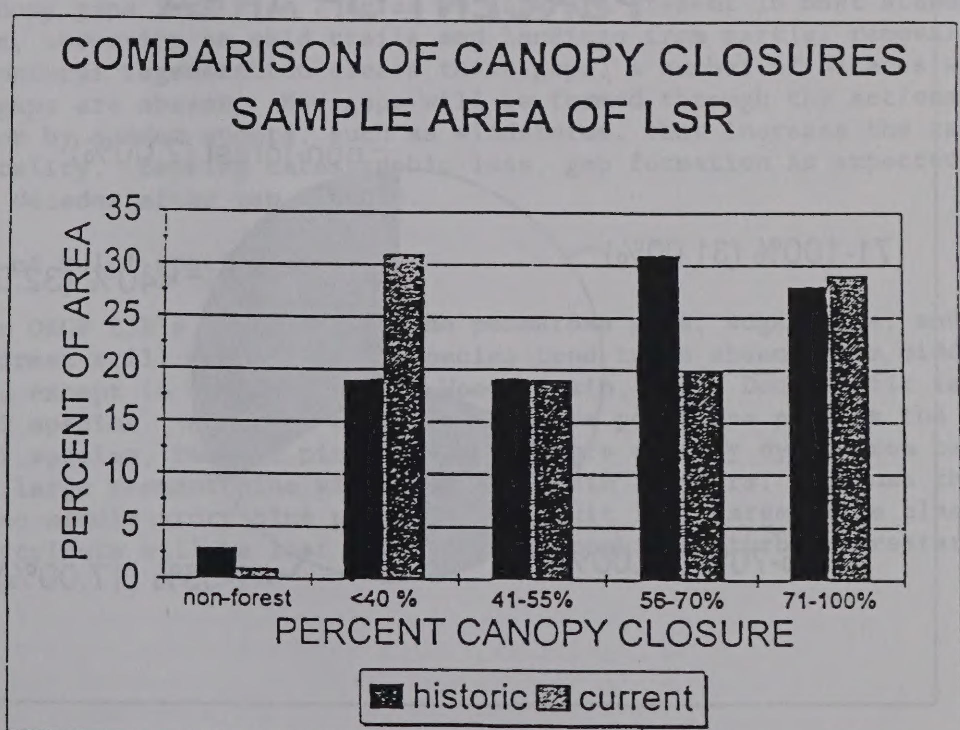


FIGURE 6. COMPARISON OF HISTORIC AND CURRENT CANOPY CLOSURE IN A SAMPLE AREA OF THE OECP LSR'S.

3. Large Trees

Approximately 16% of the OECP LSR's is comprised of stands dominated by trees greater than 20" in diameter. Another 15% of the LSR's is comprised of stands dominated by small trees, with trees greater than 20" making up roughly 30% of the overstory canopy. Typically, seral tree species are absent from the understory, and the few individuals present have no capability of achieving large tree status because of the effects of middlestory suppression. Mortality of existing large ponderosa pine is occurring, as discussed below. True fir has the ability to achieve large size under current conditions, but the crown structure of these trees is not preferred for nesting by spotted owls or bald eagles. Large true fir trees also do not persist as long as ponderosa pine or Douglas-fir, because of their susceptibility to root rots, trunk rots, and ground fires.

4. Canopy Closure

Canopy closure is generally high in the OECP LSR's. Approximately half of the LSR's are covered with stands that have canopy closures of 56% or greater (Figure 7.). A third of the LSR's have canopy closures greater than 70%. Canopy closures are expected to increase as stands mature, although insects and disease will act to reduce canopy closure in some stands. Catastrophic disturbances would open the canopy below the desirable spotted owl range.

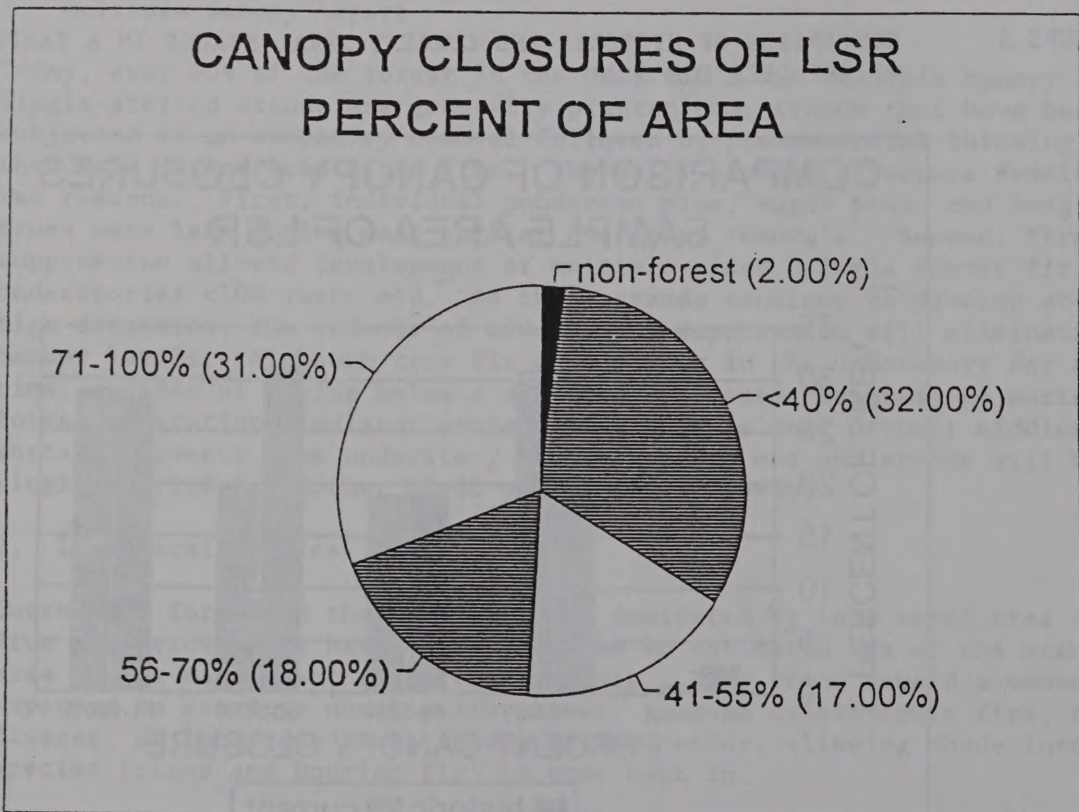


FIGURE 7. CANOPY CLOSURE IN THE OCEP LSR'S.

5. Coarse Woody Debris and Snags

Within the OECP LSR's, past regeneration harvests covering about three percent of the area left units with low levels of coarse woody debris and snags. However, in the mixed conifer CW-C2-15 plant association, this deficit no longer exists, because of recent mortality caused by fir engraver beetles. In this association, many stands now exhibit up to 60 snags per acre. Typically, these snags are in the smaller (less than or equal to 16" in diameter) size classes. As these snags fall during the next 20 years, nearly 30 tons per acre of debris will cover the forest floor. This amount of debris in the smaller size classes is excess to the needs of small mammals and nutrient cycling, and will predispose the forest to catastrophic fire (Jahns et al., 1994).

Levels of woody debris needed to preserve ecosystem function have been computed at 7-18 tons per acre in the northern Rockies (Graham et al., 1994). These levels have been refined for the Klamath Ranger District to be 7-14 tons per acre in the white fir zone and 11-18 tons per acre in the Shasta red fir zone (Appendix D.). Calculations (using 12-14" true fir as the average snag) show that small diameter snag densities of 10 per acre in the white fir zone and 15 per acre in the Shasta red fir zone will sustain woody debris levels, given current decomposition and snag longevity assumptions. Future mortality rates are expected to exceed these computed levels (Jahns et al., 1994).

Large diameter woody debris is not abundant in the OECP LSR's, with a majority of stands having 0-2 tons per acre. Large snags have been recently created by pine beetle activity in ponderosa pine, but generally average less than 5 per acre.

6. Canopy Gaps

Currently, canopy gaps less than 2 acres in size are present in most stands of the OECP LSR's, occurring as skid trails and landings from partial removal logging. As natural regeneration closes these gaps, a number of decades will follow where gaps are absent. New gaps will be formed through the actions of root disease or by random events, such as windstorms, that increase the rate of overstory mortality. Barring catastrophic loss, gap formation is expected to recur several decades after gap closure.

7. Retention of Multi-species

In most of the OECP LSR's, remnants of the ponderosa pine, sugar pine, and Douglas-fir forest still exist. Seral species tend to be absent from middle canopy layers, except in the Lake of the Woods Basin, where Douglas-fir is the dominant seral species. At lower elevations, where ponderosa pine is the dominant seral species, remnant pine overstories are rapidly dying from beetle attack. Most large remnant pine will be lost within 10 years. Because there typically is no middle-story pine present to recruit into larger size classes, this forest attribute will be lost until a catastrophic disturbance restarts succession.

H. LSR R0227 - Western Oregon Cascades Province

Like the eastern portion of LSR R0227, the western portion also consists predominately of white fir or Shasta red fir plant associations. Douglas-fir forest occurs at the lower elevations. (See Map H-3 and Figure 8.)

Plant Associations	R0227 (west)
White Fir	77%
Shasta red fir	11%
Mountain hemlock	3%
Douglas-fir	9%

FIGURE 8. PLANT ASSOCIATIONS IN LSR R0227 (WEST).

Although there is not a sharp physical division at the crest, differences in climate between the western and eastern portions of LSR R0227 are significant. In general, the westside has longer growing seasons, less frost damage, and greater precipitation (35-60" vs 25-40") than the eastside (Atzet and McCrimmon, 1990). These factors promote greater site potential, a higher percentage of Douglas-fir than ponderosa pine as a seral component, upland understories with hardwoods and pacific yew (which occur only in riparian areas on the eastside), and greater accumulations of lichens and bryophytes.

Approximately 29% of the western half of LSR R0227 is currently in a late successional condition and 44% meets the requirements of NRF habitat. NRF is sustainable throughout the western portion. Approximately 13% of the area is incapable of producing NRF.

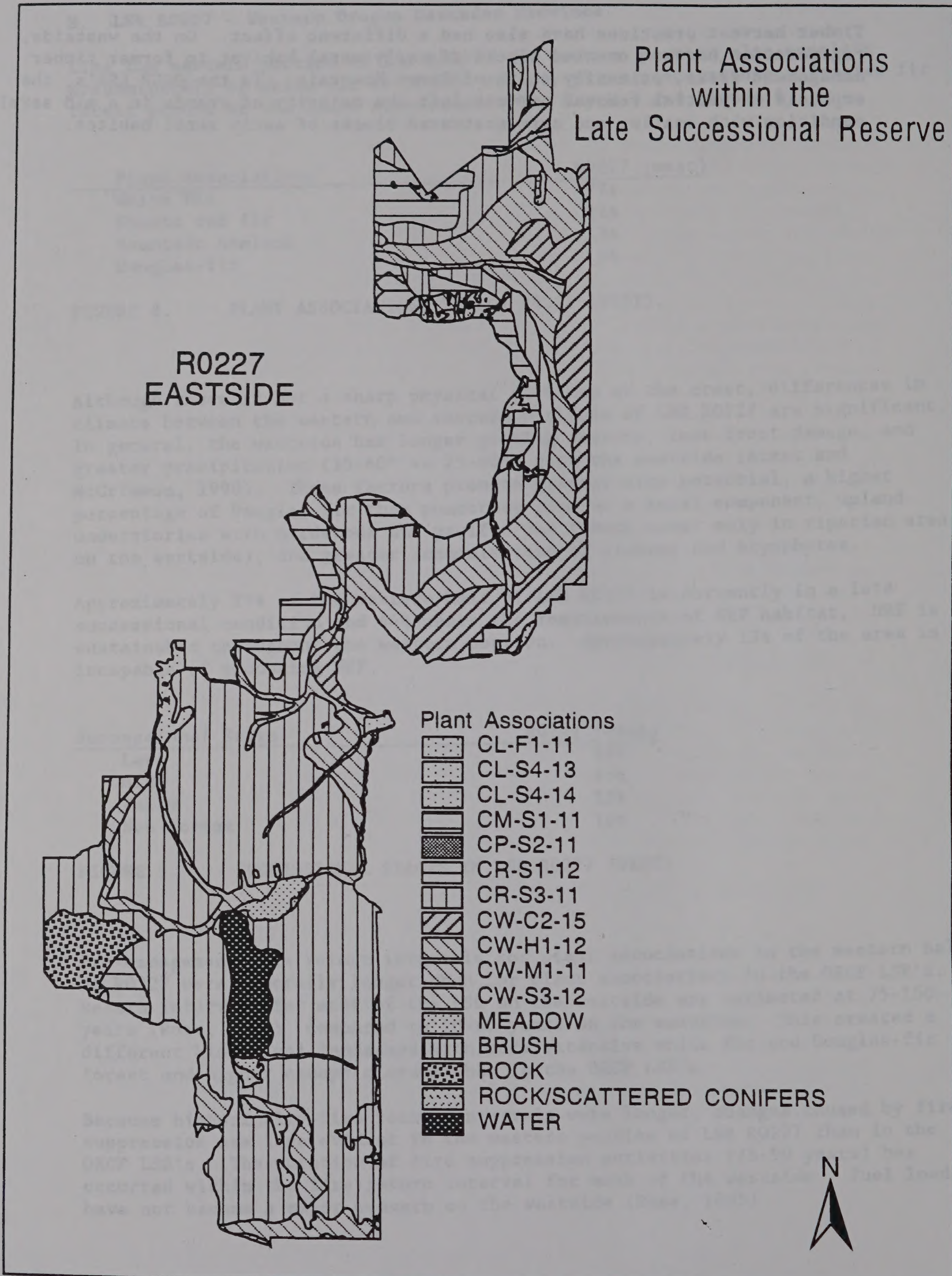
Successional Stage	R0227 (west)
Late	29%
Mid	45%
Early	12%
Non-forest	10%

FIGURE 9. SUCCESSIONAL STAGES IN LSR R0227 (WEST).

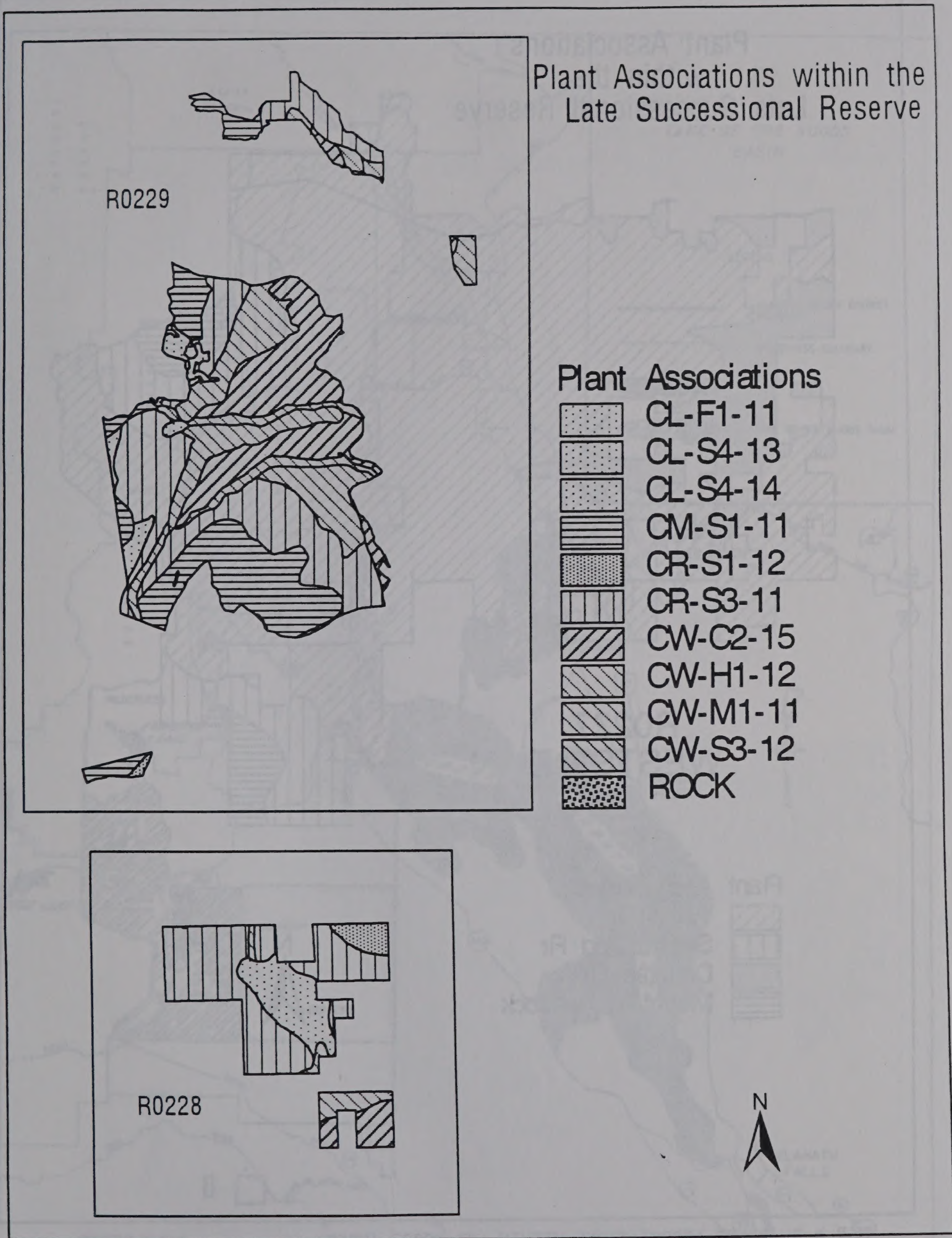
Pre-management fire return intervals for plant associations in the western half of R0227 were generally longer than for plant associations in the OECP LSR's. Return intervals for most of the LSR on the westside are estimated at 75-150 years (Rose, 1995), compared to 10-60 years on the eastside. This created a different historical landscape with more extensive white fir and Douglas-fir forest and higher canopy closure than in the OECP LSR's.

Because historically fire return intervals were longer, changes caused by fire suppression are less evident in the western portion of LSR R0227 than in the OECP LSR's. The duration of fire suppression activities (75-90 years) has occurred within the fire-return interval for much of the westside. Fuel loads have not become a major concern on the westside (Rose, 1995).

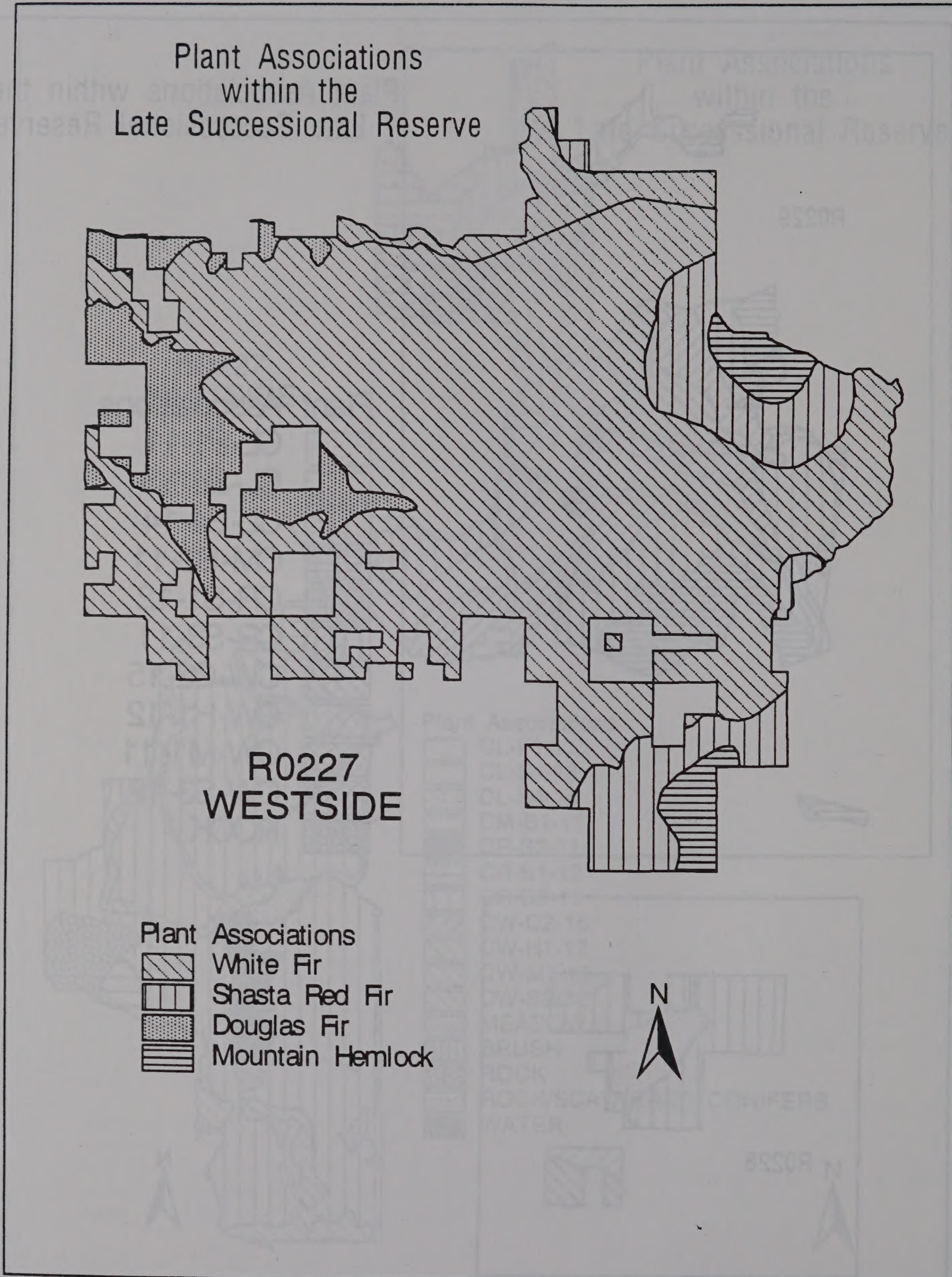
Timber harvest practices have also had a different effect. On the westside, regeneration harvest created blocks of early seral habitat in former timber management areas, primarily south of Brown Mountain. In the OECP LSR's, the emphasis on partial removal harvest left the majority of stands in a mid seral condition with smaller and more scattered blocks of early seral habitat.



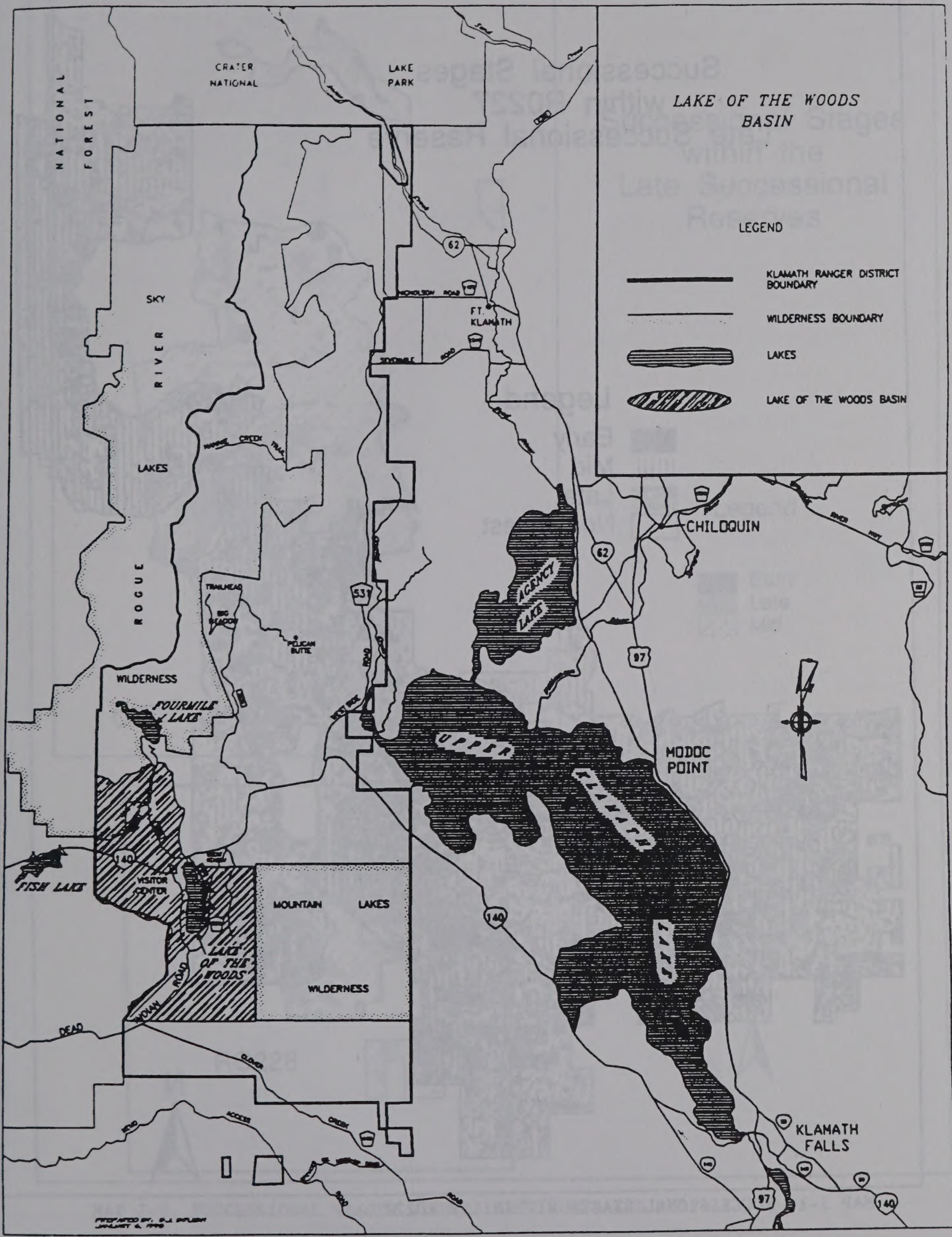
MAP H-1. PLANT ASSOCIATIONS WITHIN LSR R0227 (EAST).



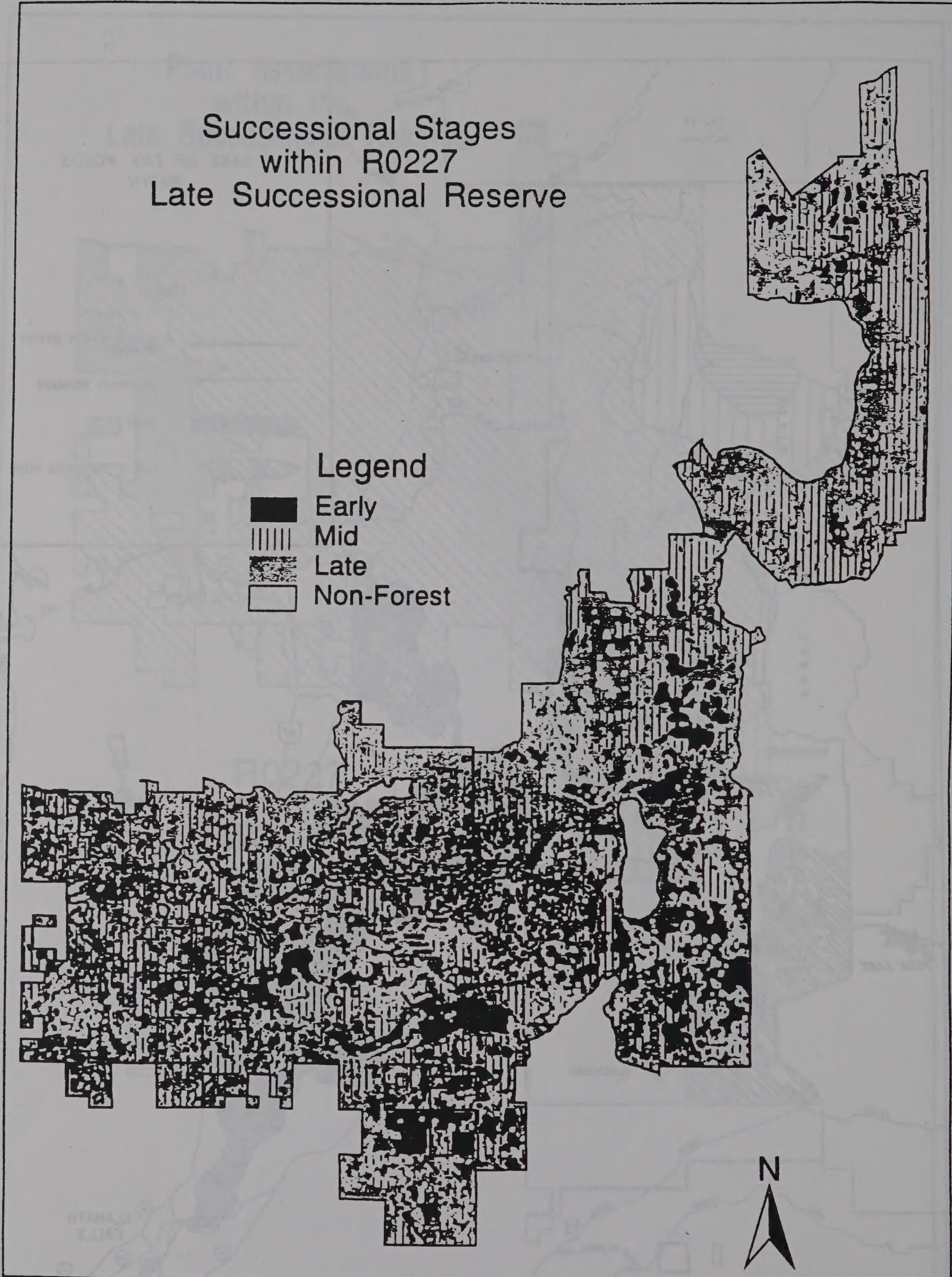
MAP H-2. PLANT ASSOCATIONS WITHIN LSR'S R0228 AND R0229.



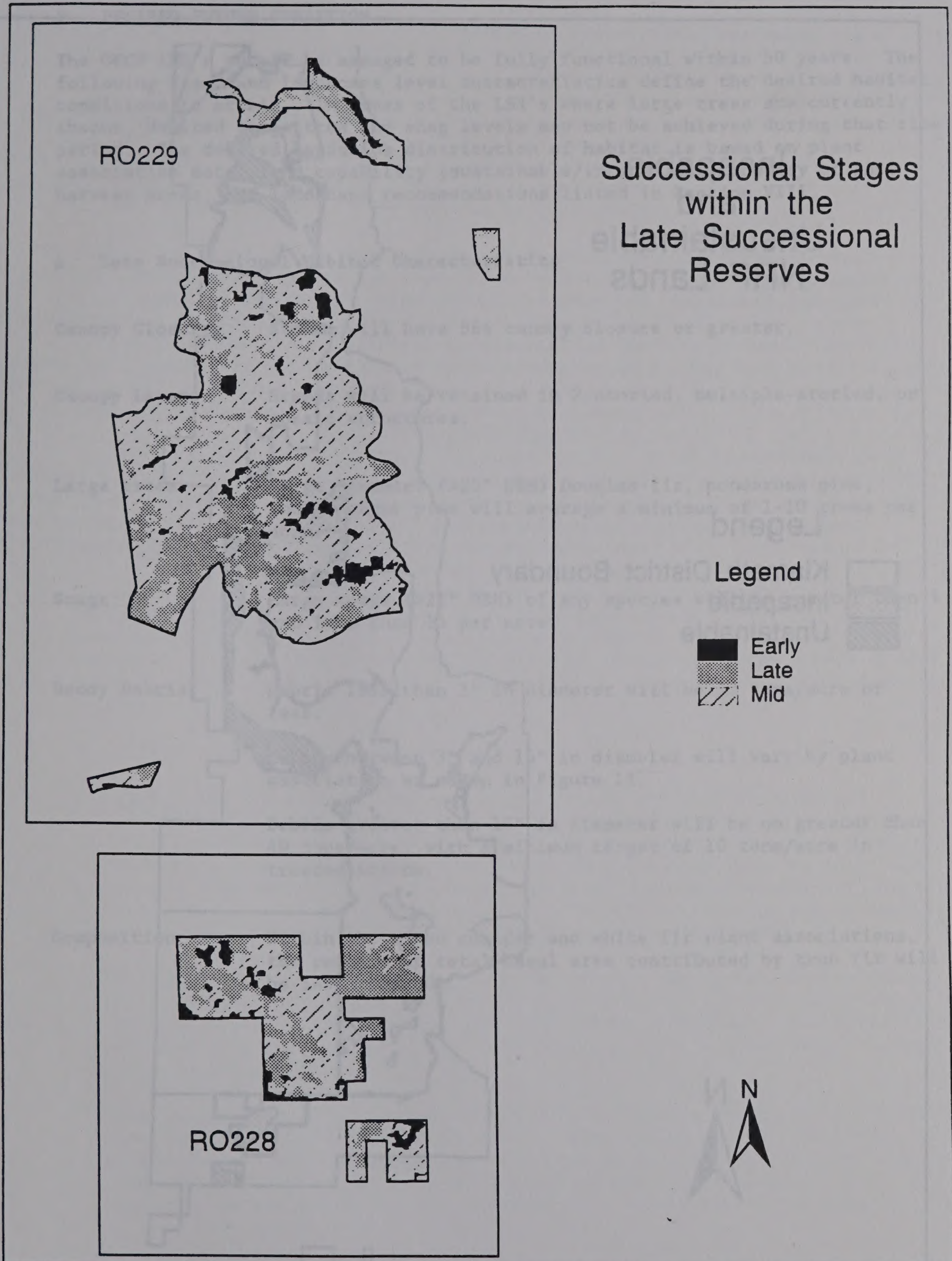
MAP H-3. PLANT ASSOCIATIONS WITHIN LSR R0227 (WEST).



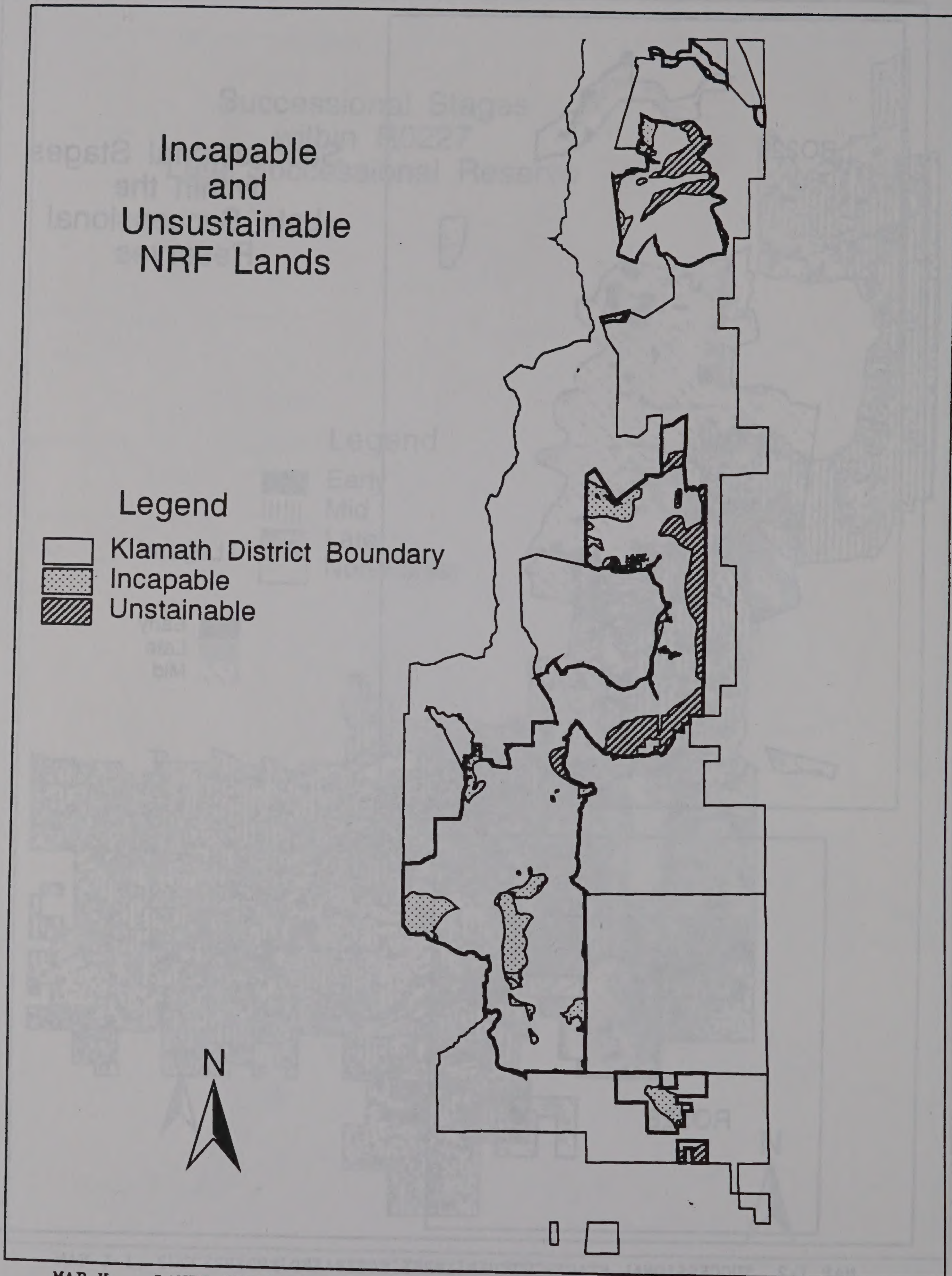
MAP I. LOCATION OF THE LAKE OF THE WOODS BASIN.



MAP J-1. SUCCESSIONAL STAGES WITHIN LSR R0227.



MAP J-2. SUCCESSIONAL STAGES WITHIN LSR'S RO228 AND RO229.



MAP K. LANDS INCAPABLE OF DEVELOPING OR SUSTAINING NRF IN THE OECP LSR'S.

V. DESIRED FUTURE CONDITION

The OECP LSR's should be managed to be fully functional within 50 years. The following stand and landscape level characteristics define the desired habitat conditions to attain. In areas of the LSR's where large trees are currently absent, desired large tree and snag levels may not be achieved during that time period. The desired landscape distribution of habitat is based on plant association data, land capability (sustainable/incapable), recovery of past harvest areas, and landscape recommendations listed in Section VIII.

A. Late Successional Habitat Characteristics

Canopy Closure: Stands will have 56% canopy closure or greater.

Canopy Layers: Stands will be retained in 2-storied, multiple-storied, or mosaic structures.

Large trees: Large diameter (>25" DBH) Douglas-fir, ponderosa pine, and/or sugar pine will average a minimum of 1-10 trees per acre.

Snags: Large snags (>22" DBH) of any species will be greater than 5 and less than 15 per acre.

Woody Debris: Debris less than 3" in diameter will be 12 tons/acre or less.

Debris between 3" and 16" in diameter will vary by plant association as shown in Figure 11.

Debris greater than 16" in diameter will be no greater than 40 tons/acre, with a minimum target of 10 tons/acre in treated stands.

Composition: Within the mixed conifer and white fir plant associations, the percent of total basal area contributed by true fir will be less than 60%.

B. Landscape Distribution of Habitat

Late Successional Meeting NRF	At least 50% of the landscape will consist of late successional stands which meet NRF criteria and have the characteristics listed above. This habitat will occur in white fir and Shasta red fir stands and will be distributed evenly across the LSR's on sites where it is sustainable. Continuity of habitat will be improved over time.
Late Successional and Other Habitat Meeting Dispersal	Habitats which cannot sustain high stand densities, are managed for bald eagle habitat, are recovering from past harvest, or are otherwise incapable of producing the characteristics listed above will comprise approximately 25% of the landscape. Included in this category are unsustainable mixed conifer stands and many of the incapable forest lands (mountain hemlock, old growth lodgepole, rocky sites, etc.), which have sufficient canopy and tree size to meet dispersal requirements.
Other Habitat Not Meeting Dispersal "Open"	No more than 25% of the landscape will be in open habitat. This will include non-forested lands, areas of past harvest or disturbance, and stands where the canopy is too sparse or the tree size too small to meet dispersal requirements (for example, small diameter lodgepole pine).

VI. AGENTS OF RISK

Past management has generated a number of risk factors which could cause significant mortality at the landscape scale. Risk factors, such as wildfire, insects, diseases, and windthrow, were analyzed to see which are likely to have significant effects on the stability of late successional forest in the OECP LSR's.

A. Fire Hazard and Risk

1. Fire Hazard

"Fire hazard" was determined from the existing fuels and fuels being created. Fuel models were used as a measure of fire hazard. Fuel models are tools to help the user realistically estimate fire behavior, based on fuel group (grasses, brush, timber, slash), fuel load, the quantity of fuels (generally measured in tons per acre), and the distribution among the fuel particle size classes. Fuel load and depth are important properties for predicting whether a fire will be ignited and its rate of spread and intensity. The criteria for choosing a fuel model include the fact that fire burns in the fuel stratum best conditioned to support the fire (Anderson, 1982). It is acknowledged that fuel models do not give a complete picture of fire hazard. Many stands in the OECP LSR's have dense small diameter white fir understories. This "ladder fuel" structure increases the chance for development of a crown fire, despite moderate levels of fuels on the ground.

The OECP LSR's are most representative of fuel models 8, 9, 10, 11, and 12 (Anderson, 1982). Healthy stands at high elevations are classified as fuel model 8, while fuel model 9 occurs in lower elevation healthy stands. Fuel models 10, 11, and 12 describe the majority of stands with high mortality and heavy loadings of downed material, or areas with untreated slash from previous logging.

These fire behavior models are described as follows:

<u>Fuel model 8:</u> Slow-burning ground fires with low flame lengths are generally the case, although the fire may encounter an occasional heavy fuel concentration that can flare up. Only under severe weather conditions involving high temperatures, low humidities, and high winds do the fuels pose a fire hazard. Closed canopy stands of short-needle conifers, such as white fir, are included in this model. The litter layer is mainly needles and twigs. The stands usually have very little undergrowth.

<u>Fuel model 9</u>: In this model, fires run through the surface litter faster than in fuel model 8 and have longer flame heights. Long-needle conifer stands, such a ponderosa pine, are included in this model. Concentrations of dead-down woody material will contribute to possible torching of trees, spotting, and crowning.

<u>Fuel model 10</u>: In this model, fires burn in surface and ground fuels with greater fire intensity than the other timber litter models. Dead-down fuels include greater quantities of 3-inch or larger limbwood resulting from overmaturity or natural events that create a large load of dead material on the forest floor. Crowning out, spotting, and torching of

individual trees are more frequent in this fuel situation, leading to potential fire control difficulties. Examples are insect or disease-ridden stands, windthrown or overmature situations with deadfall, and aged light thinning or partial-cut slash.

Fuel model 11: The fires that burn in this model are fairly active in slash and herbaceous material intermixed with slash. The spacing of the rather light fuel load, shading from overstory, or the aging of the fine fuels can contribute to limiting the fire potential. Light partial cuts or thinning operations in mixed conifer stands are indicative of this model.

Fuel Model 12: Fuel Model 12 is similar to Fuel Model 11 except that the fuel loadings are heavier and more continuous. In combination with ladder fuels, this model has a high potential for a crown fire.

Before the advent of fire suppression, low elevation forests in the OECP LSR's had relatively low stocking levels and were dominated by ponderosa pine. Ground fires kept these stands open and park-like. Individual trees were occasionally torched. Fuel models 8 and 9 were likely common in the pre-management forest. Currently, stand densities are often more than double those which existed prior to fire suppression, and are dominated by small diameter true fir species. Inventory of approximately 67% of the OECP LSR's show high hazard fuel models 10, 11, and 12 now occur over 27% of the inventoried area (Map L-1) and are increasing in distribution. Crowning out, spotting, and torching of individual trees are more likely to occur in these fuel situations, leading to potential fire control difficulties. These fuel models, combined with the dying overstory, are predisposing the District to a catastrophic occurrence.

Fuel models in the Lake of the Woods Basin and Shasta red fir zone are primarily model 8, similar to pre-management conditions.

2. Fire Risk

"Fire risk" is based on the relative chance of an ignition. The risk of fire on the Klamath Ranger District has not substantially changed since pre-management times. Lightning strikes are still the primary cause of ignition. The District has had an average of 23 fires per year (both natural and human-caused) from 1961 to 1992 (Map M). Fires have occurred at a rate of .12 per 1000 acres. The probability of a fire occurring on the Klamath Ranger District on any given day between May 1 through October 1 is 16%. The probability of a fire within the LSR being 0-1/4 acres in size is 92%; 1/4 to 9 acres, 7%; and the probability of a fire being larger than 10 acres is less than 1%.

Although the risk of ignition has remained the same, the probability of a fire growing beyond suppression capabilities has increased, due to changes in fuels. Future conditions resulting from insect and disease-caused mortality are likely to increase fire hazard to extreme levels.

B. Insects and Disease

Map N and Figure 10 show the general distribution of areas which are at risk from mortality caused by insects and disease in the OECP LSR's. The primary insect and disease agents on the Klamath Ranger District are discussed in this section.

LSR	Insect and Disease Risk
RO227 (east)	29%
RO228	12%
RO229	33%

FIGURE 10. MAGNITUDE AND DISTRIBUTION OF AREAS IN THE OECP LSR'S AT RISK TO MORTALITY FROM INSECTS AND DISEASE.

1. Western and Mountain Pine Beetles

Pine beetles are natural regulators of forest ecosystems east of the Cascades. In a natural system, these insects provide stocking level control in ponderosa pine stands. Beetles are attracted initially to pines that are under stress, often because of overstocking, drought, or damage. Once a stressed tree has been successfully invaded, pheromones emitted by invading beetles attract additional beetles to the same tree, overpowering the tree's defenses (Eglitis, 1993).

The primary defense of a ponderosa pine is its pitch. When a beetle invades a healthy tree, the tree responds by producing pitch in sufficient quantities to exude out the beetle's entry hole. The invading beetle is ejected from the tree with the flow of pitch, and produces no pheromone to attract additional beetles. When a tree is under moisture stress, however, this defense mechanism is disabled. Multiple attacks on a single tree can easily cause mortality.

Good indicators of moisture stress include diameter growth rates and stand basal area. If a ponderosa pine tree is growing at the rate of 1.5" of diameter growth per decade or greater, the tree is typically able to repel beetle attack. This growth rate is approximated when the stand basal area is 150 sq. ft./acre or less (Sartwell and Stevens, 1975). In individual drought years, a tree may be vulnerable, but mortality can be characterized as incidental when these growth and stocking guidelines are followed.

In the pre-management forest, overstocking was not common because frequent ground fires thinned stands. Stocking levels were kept at relatively low levels, and pine beetles existed at endemic levels, removing individual trees weakened by other agents. In the current forest, however, stand densities are frequently as high as 300 sq. ft./acre. Consequently, ponderosa pines in stands that have not been treated with thinning or underburning are at risk of bark beetle-induced mortality. Although beetle populations are not currently at epidemic levels, the cumulative effects of mortality from endemic populations can be severe.

The consequences of District-wide ponderosa pine mortality are extreme. Ponderosa pine is one of the preferred nesting trees for the bald eagle and the spotted owl (Anthony et al., 1982; Issacs, 1993; Hardy, 1994). The ponderosa pine population on the Klamath Ranger District is also genetically distinct. Once this gene pool is lost or further narrowed, opportunities for ecosystem restoration could be diminished. Losing this last vestige of the pre-management ponderosa pine forest will reduce species diversity in the OECP LSR's.

2. Fir Engraver Beetle

The biology of the fir engraver beetle is similar to that of pine beetles, except its host species are true firs. Mortality caused by fir engraver beetles occurred at low levels until 1992, when beetle populations started approaching epidemic levels. At low population levels, the beetle acts as a thinning agent, killing individual moisture-stressed trees. Typically, mortality is associated with Armillaria root rot pockets at these levels (Eglitis, 1993). However, in 1993, beetle kill became a stand-replacing event at lower elevations where moisture stress is greatest. The Lake of the Woods Basin has not been affected, nor have higher elevation Shasta red fir forests, although they are considered susceptible. In effect, the fir engraver beetle is defining where high canopy closure is sustainable.

Research has yet to define stand density levels that have a low risk of infestation. White fir stands which exceed the theoretical site potential for the plant association are considered to be at high risk. In assessing risk, we assumed that a stand is at risk when the stand composition is more than 40% true fir, the stand is located in a white fir ecoclass, and stand density exceeds the site potential for the plant association, as described by Hopkins (1979).

The consequences of fir engraver outbreaks are less severe than pine beetle outbreaks, because of the abundance of true fir in the LSR's. However, white fir provides the multi-storied canopy structure and canopy closure that spotted owls prefer for nesting, roosting, and foraging. When stand-replacing levels of mortality occur, stands lose suitability for spotted owl habitat. Under endemic fir engraver levels, canopy structure and closure are not jeopardized. However, serious indirect effects can occur. The build up of fuels over time from persistent, low levels of fir mortality can increase fire hazard.

3. Armillaria Root Rot

Armillaria root rot is a soil fungus native to Central Oregon. It can exist as a saprophyte, or as a lethal tree parasite. Often it infects the root systems of trees, but is not lethal, because of biochemical resistance present in the host. This resistance fades when the tree is under stress, creating pockets of mortality. Common stressors include overstocking, drought, soil compaction, and defoliation. Mortality is often in concert with the insect regulators previously mentioned (Shaw and Kile, 1991).

Armillaria can cause mortality of any of the conifers native to the OECP LSR's. White and Shasta red fir are least resistance to the fungus, Douglas-fir has some resistance, and pine species are moderately resistant. Although widespread on the District, Armillaria does not have the explosive potential to

kill trees that the insects have. Infections spread through rhizomorphs in the soil, which progress outward from a center at an average rate of 6 feet per year. Highest mortality rates are at low elevations in LSR R0229 and at the northern end of LSR R0227. Armillaria mortality is low in the Lake of the Woods Basin and LSR R0228.

The fungus can live in the stumps and root systems of killed trees as a saprophyte for decades. Consequently, when seedling roots come in contact with old infected root systems, the new generation becomes infected and succumbs as well. Unless resistant species are introduced into Armillaria pockets, the site may remain unforested for decades. This scenario is likely under natural conditions when natural regeneration is confined to true fir trees.

Silvicultural treatments have a variety of effects on an infected stand. Generally speaking, stocking level control favoring resistant species is advised to improve the resistance of the residual stand (Maffei, 1993). If the stocking level control is attained through an overstory removal, however, an imbalance between inoculum in the soil and host biomass may be triggered, producing accelerated mortality in the residual stand. Improper use of mechanical equipment that compacts the soil may accelerate tree mortality as well (Maffei, 1993).

The consequences of Armillaria infection are mixed. In its early stages, the disease creates canopy gaps and snags that are representative of a late successional forest. These conditions are considered ideal for the prey base of the spotted owl. As the mortality continues, an opening is created at a scale that is no longer suitable for owl foraging. The opening is likely to persist for decades, unless resistant species are introduced. The snags that are created are often too small to be of use to most cavity nesters and can create fuel buildup.

4. White Pine Blister Rust

White pine blister rust, caused by the fungus Cronartium ribicola was introduced into western America in 1910. Infection of five-needle pines in the South Cascades became common by the mid 1920s, infecting and killing pines over a large area. White pine blister rust requires an alternate host in the genus Ribes and is greatly favored by moist conditions in late summer and fall. On sites where these conditions occur, it kills most susceptible young pines and causes top kill and branch flagging in large hosts. Larger hosts are often weakened and subsequently attacked by bark beetles. Due to a general lack of resistance to the fungus in five-needle pine populations and the associated bark beetle-caused mortality, western white pine and sugar pine trees have been greatly reduced in many areas where they were historically important. Although a breeding program has been successful in identifying resistance to the fungus, resistant stock has only recently become available (Goheen, 1997).

C. Windthrow

The risk of windthrow on the Klamath Ranger District is low compared to other locations in the Pacific Northwest, but isolated incidents can occur. We analyzed windthrow salvage sales which occurred over the past 10 years to determine windthrow patterns. In unharvested stands, windthrow was confined to ridgetops, other exposed sites with shallow soils, and to sites with high water

tables. In harvested stands, windthrow occurred primarily on the edges of clearcuts and in thinnings and shelterwood cuts. Presence of Armillaria or Indian paint fungus also promoted windthrow, independent of whether the stand was harvested. Some windthrow events were random, and could not be related to any of the above factors. Within the OECP LSR's there are no areas that are unusually susceptible to windthrow (Jahns and Augustine, 1993).

In shelterwood cuts of stands with an all-aged stand structure, windthrow is not a problem in the true fir forest (Laacke, 1990). In this case, the dominants have been in an exposed position for their whole lives and have root systems developed to withstand windshear. Instability may be induced in shelterwood or thinning cuts in even-aged stands, where preharvest windfirmness is more a function of stand density. Typically, this problem is encountered when the height/diameter ratio exceeds 75; that is, when a 12" diameter tree exceeds 75 feet in height (Oliver, 1994).

Windthrow can create snags and replenish coarse woody debris. Typically, excessive risk of fire is not an associated effect, because incidents are small and isolated and primarily large fuels are created. These benefits come at the expense of large trees, however, which may be in short supply and are not replaced for long periods of time. Loss of the overstory can remove the protection from a frost-sensitive understory on some sites, causing further understory mortality. Through proper silvicultural treatments, stand-level windthrow events can be avoided in most cases.

D. LSR R0227 - Western Cascades Province

1. Fire Hazard and Risk

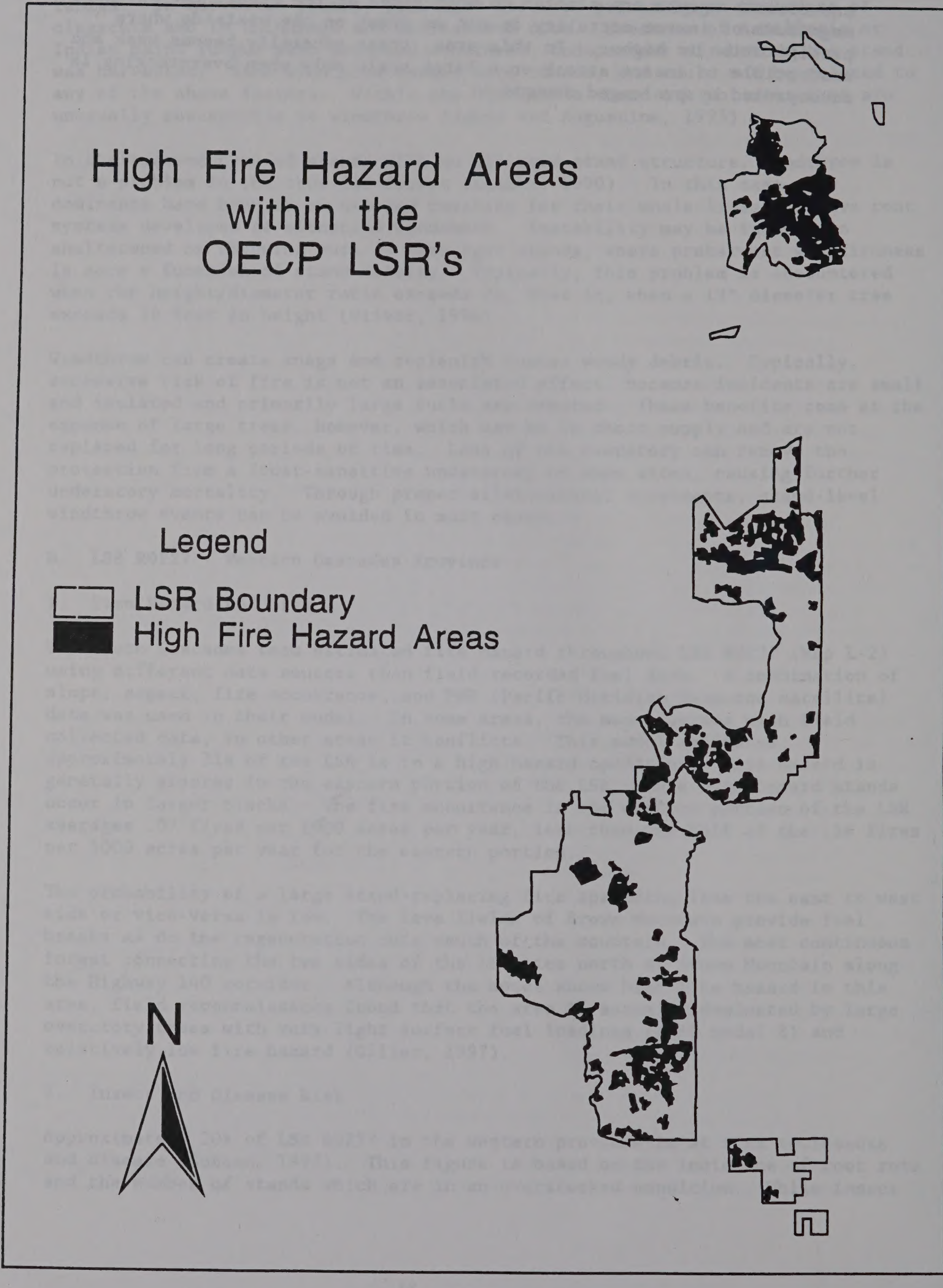
The South Cascades team estimated fire hazard throughout LSR R0227 (Map L-2) using different data sources than field recorded fuel data. A combination of slope, aspect, fire occurrence, and PMR (Pacifc Meridian Resource satellite) data was used in their model. In some areas, the model agrees with field collected data, in other areas it conflicts. This model estimates approximately 31% of the LSR is in a high hazard condition. Fire hazard is generally greater in the eastern portion of the LSR, where high hazard stands occur in larger blocks. The fire occurrence in the western portion of the LSR averages .07 fires per 1000 acres per year, less than one half of the .16 fires per 1000 acres per year for the eastern portion.

The probability of a large stand-replacing fire spreading from the east to west side or vice-versa is low. The lava fields of Brown Mountain provide fuel breaks as do the regeneration cuts south of the mountain. The most continuous forest connecting the two sides of the LSR lies north of Brown Mountain along the Highway 140 corridor. Although the model shows high fire hazard in this area, field reconnaissance found that the area is actually dominated by large overstory trees with very light surface fuel loadings (fuel model 8) and relatively low fire hazard (Giller, 1997).

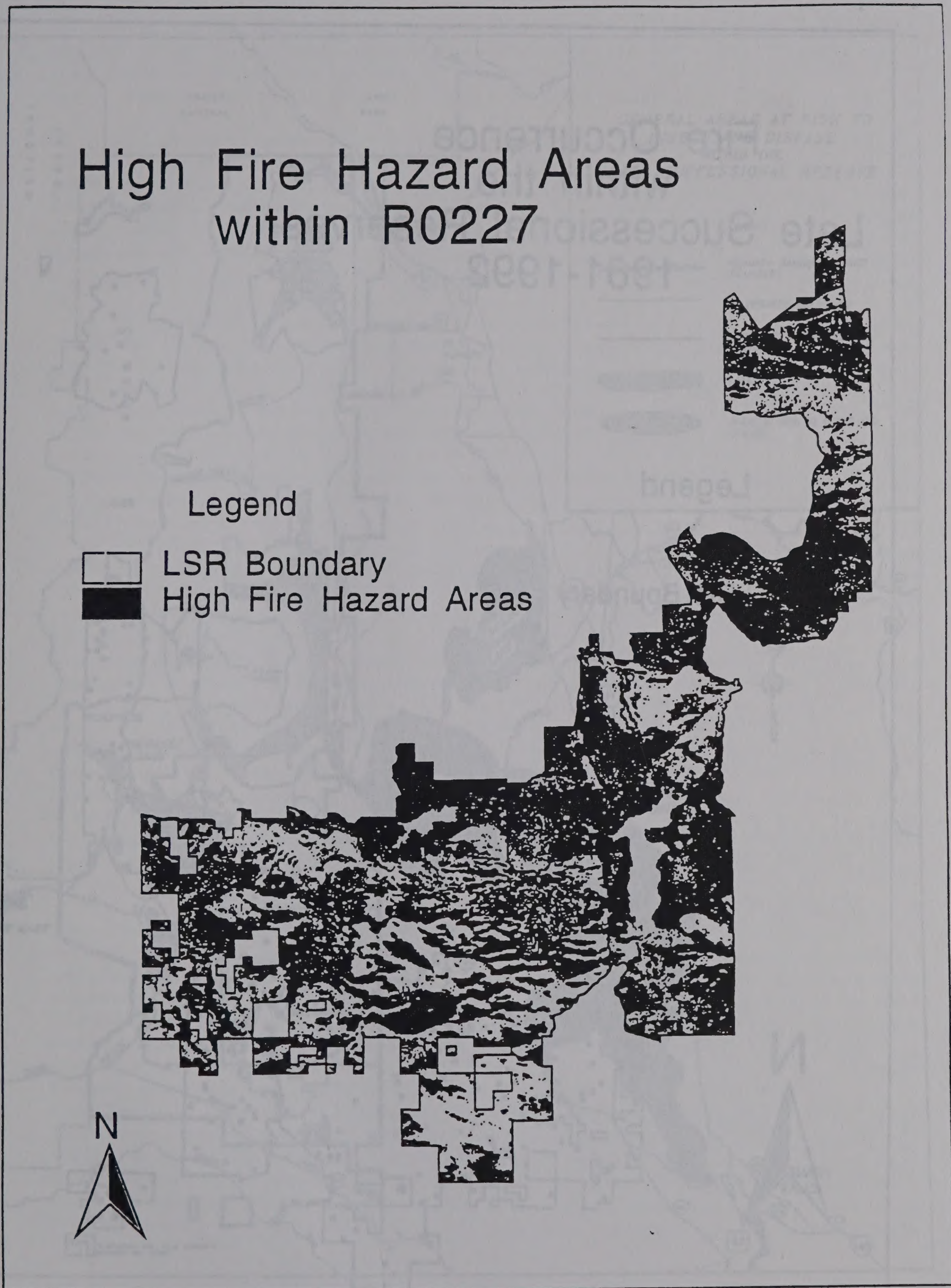
2. Insect and Disease Risk

Approximately 20% of LSR R0227 in the western province is at risk to insects and disease (Goheen, 1997). This figure is based on the incidence of root rots and the number of stands which are in an overstocked condition. While insect

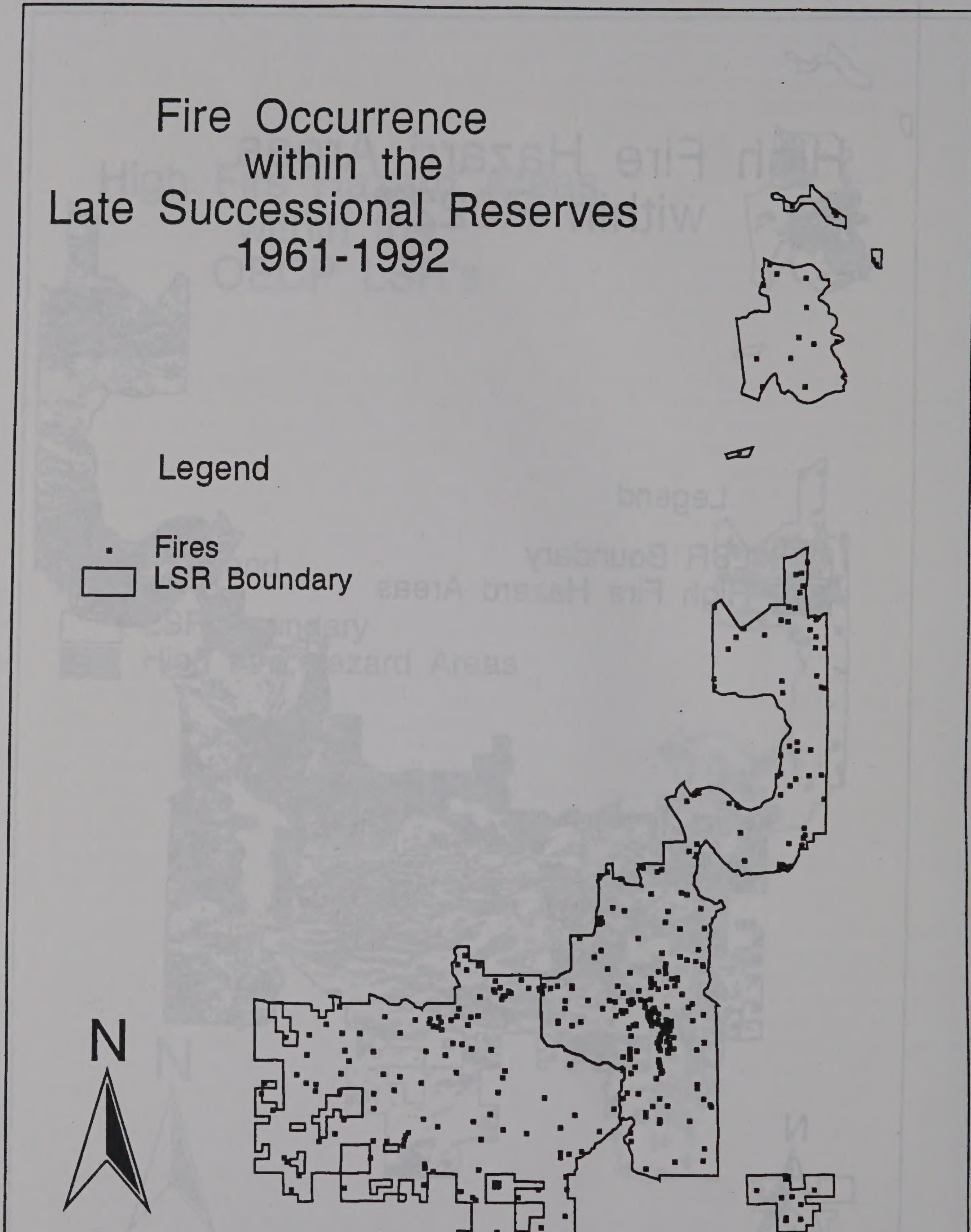
and disease agents are similar on both sides of the crest, the extent and magnitude of insect mortality is not as great on the westside where precipitation is higher. In this area, trees generally become weak and susceptible to insect attack on a large scale only when overstocking is accompanied by prolonged drought.



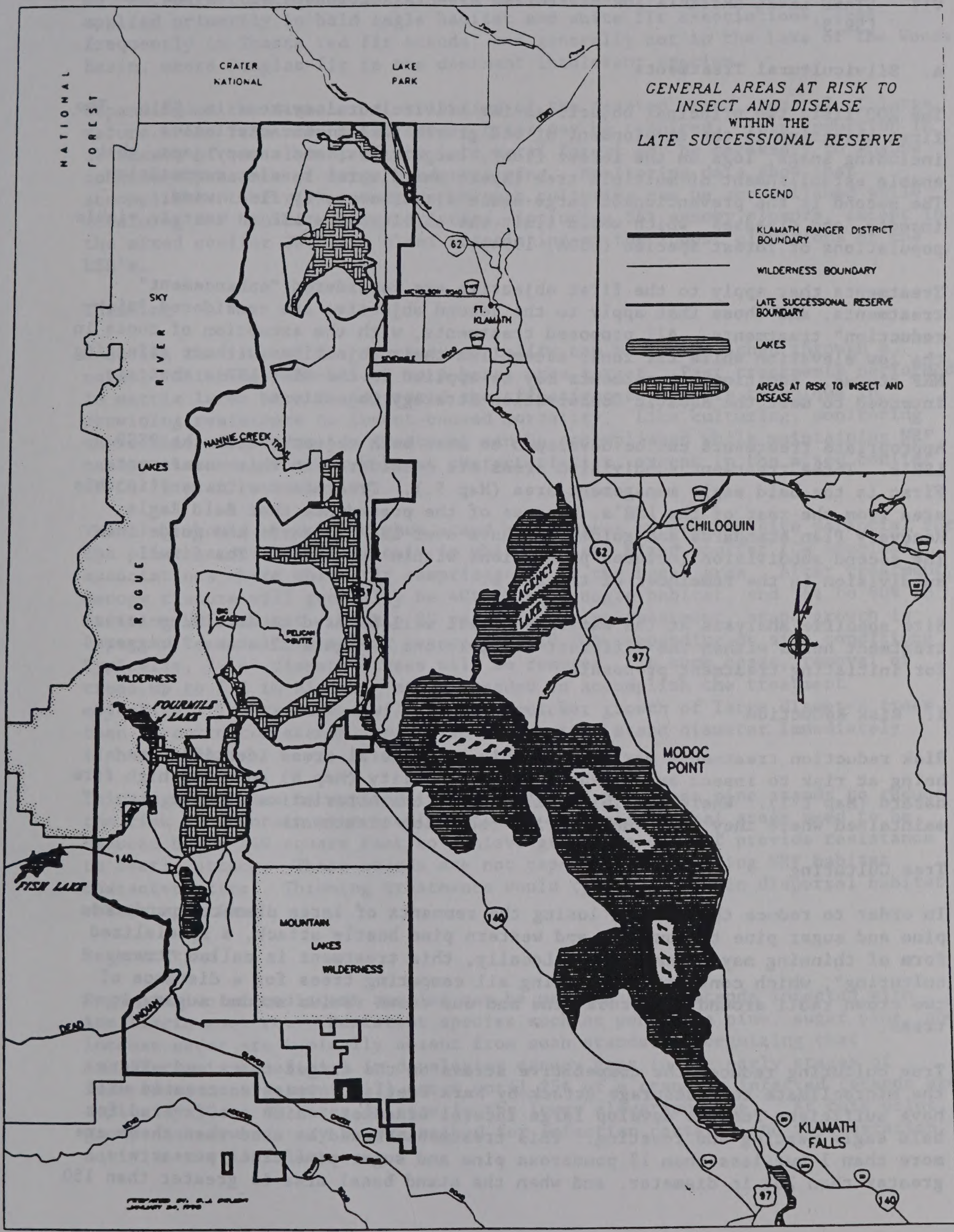
MAP L-1. HIGH FIRE HAZARD AREAS IN THE OECP LSR'S DETERMINED BY FIELD SURVEYS.



MAP L-2. HIGH FIRE HAZARD AREAS IN LSR R0227 DETERMINED BY MODELING.



MAP M. FIRE OCCURRENCE IN THE LSR'S FROM 1961-1992.



MAP N. GENERAL AREAS AT RISK TO INSECTS AND DISEASE IN THE OECP LSR'S.

VII. STAND-LEVEL CRITERIA FOR DEVELOPING APPROPRIATE TREATMENTS IN THE OECP LSR'S

A. Silvicultural Treatments

The ROD lists two principal objectives for silvicultural systems in LSR's. The first objective is the development of old-growth forest characteristics, including snags, logs on the forest floor, large trees, and canopy gaps, that enable establishment of multiple tree layers and diverse species composition. The second is the prevention of large-scale disturbances by fire, wind, insects, and diseases, which would limit the ability of a LSR to sustain viable populations of forest species (USDA, 1994).

Treatments that apply to the first objective are considered **"enhancement"** treatments, and those that apply to the second objective are considered **"risk reduction"** treatments. All proposed treatments, with the exception of those in the low elevation white fir zone, accomplish their objectives without affecting NRF status. Additional treatments may be applied to the OECP LSR's that are intended to meet the Aquatic Conservation Strategy Objectives.

Appropriate treatments can be developed to meet both objectives in the OECP LSR's. Three treatment subdivision areas are considered in this assessment. First is the bald eagle management area (Map F.). Treatments will vary in this area from the rest of the LSR's, because of the precedence that Bald Eagle Recovery Plan standards and guidelines have over LSR standards and guidelines. The second subdivision includes plantations within the LSR's. The final subdivision is the remainder of the LSR's.

Site specific analysis at the watershed level will be used to determine actual treatment needs within the different subdivisions. Figure 12 shows "triggers" for initiating treatment proposals.

1. Risk Reduction

Risk reduction treatments may occur within the general areas identified as being at risk to insect and disease-caused mortality (Map N) and with high fire hazard (Map L-1). Where feasible, NRF habitat characteristics will be maintained where they exist during risk reduction treatments.

Tree Culturing

In order to reduce the risk of losing the remnants of large diameter ponderosa pine and sugar pine to mountain and western pine beetle attack, a specialized form of thinning may be employed. Locally, this treatment is called "tree culturing", which consists of removing all competing trees for a distance of two crown radii around ponderosa pine and one crown radius around sugar pine trees.

Tree culturing reduces the competitive stress on the target trees and alters the microclimate to discourage attack by bark beetles. Trees so treated will have sufficient room to develop large lateral branches, which are favored for bald eagle nesting and roosting. This treatment should be used when there are more than 1 but less than 12 ponderosa pine and sugar pine trees per acre greater than 20" in diameter, and when the stand basal area is greater than 150

sq. ft./acre (the threshold for bark beetle attack). This treatment should be applied primarily in bald eagle habitat and white fir associations, less frequently in Shasta red fir stands, and generally not in the Lake of the Woods Basin, where Douglas-fir is the dominant intolerant species.

Depending on the diameter distribution of the treated stand, removal of large, mature trees from around the target trees may be required. This reduction in abundance of one element of the late seral forest may be necessary to ensure continued presence of large ponderosa pine. Monitoring data show that accomplishment of risk reduction through culturing can be accomplished while retaining NRF habitat characteristics, including 56% canopy closure, except in the mixed conifer CW-C2-15 plant association at the lowest elevations of the LSR's.

Thinning

Reducing the risk of fir engraver mortality can be accomplished through a normal "thinning-from-below" to a basal area target. Past treatments performed in matrix lands have demonstrated the effectiveness of this technique in providing resistance to insect-caused mortality. Like culturing, monitoring shows this risk reduction treatment can be accomplished while maintaining NRF canopy closure and other habitat characteristics, except in the mixed conifer CW-C2-15 plant association.

Thinning should be applied when stand basal areas exceed the site potential for the plant association, and only in white fir and mixed conifer (CW ecoclass) associations where white fir comprises 60% of the basal area. After treatment, canopy closure will generally be 40% in bald eagle habitat, and 56% to 60% in existing NRF habitat. Within 20 years following treatment, stand growth is expected to result in canopy recovery of 10-20%, depending on site conditions. Typically, 7-14" diameter trees will be removed. In some cases, removal of trees up to 21" in diameter may be needed to accomplish the treatment objective. The treatment will promote quicker growth of large diameter trees than in untreated stands, and raise the average stand diameter immediately (Jahns, 1994).

Thinnings may also be applied in lodgepole and ponderosa pine stands to reduce the risk of mountain pine beetle attack. Typically, basal areas need to be reduced below 140 square feet to achieve growth rates that provide resistance to beetle attack. These stands are not capable of developing NRF habitat characteristics. Thinning treatments would typically retain dispersal habitat characteristics.

Regeneration

Regeneration of resistant species can be used to treat stands infected with Armillaria root rot. Resistant species such as ponderosa pine, sugar pine, and incense cedar are typically absent from such stands. Recognizing that Armillaria is beneficial in developing canopy gaps in the early stages of infection, no treatment will occur until 25% of a stand is infected (stands are typically 10 to 40 acres in size in the lower elevation zone). At this point, group shelterwoods may be prescribed for infection centers, and reforestation activities will follow.

Proceeding directly with reforestation will generally be infeasible, because of excessive amounts of coarse woody debris. The size of the group shelterwoods will be approximately 2 to 9 acres, simulating the scale of disturbance by fire under the current suppression regime. This scale was chosen because the current fire suppression regime is responsible for creating the quality and continuity of existing spotted owl habitat. This treatment will generally be prescribed in the eagle management area and white fir plant associations.

Regeneration treatments may also be used to introduce western white pine stock which is resistant to white pine blister rust.

Fuel Treatments

A number of treatments may be used to reduce fire hazard. Commercial thinnings, precommercial thinnings, or prunings may be used to break up the continuity of ladder fuels in some situations. These treatments will occur in young, overly-dense stands.

Underburning will be used primarily as a postsale activity; the high stand densities, presence of ladder fuels, and low fire resistance of true fir species make it an impractical tool prior to harvesting in most areas of the OECP LSR's. As a postsale treatment, underburning will follow regeneration harvests or thinnings which leave stands dominated by fire-resistant trees. Where stands dominated by fire-resistant trees currently exist, underburning alone may be an appropriate treatment. Underburning will occur primarily in bald eagle habitat and low elevation white fir stands.

Hand or machine piling of slash can be used to reduce the risk of catastrophic fire, when high fuel loads are concentrated in contiguous stands. Salvage sales and/or hand fell and pile treatments may be used, when small diameter coarse woody debris levels are sufficient and high snag levels indicate future risk of fuel buildup. This treatment would typically be employed where Armillaria root rot or fir engraver beetles have created high snag levels (in some stands, snag densities as high as 150 stems per acre have been counted). In other cases, infrequent blowdown events may create high hazard fuels.

Fuel treatments should be designed to retain an adequate amount of snags, coarse woody debris (3"+ diameter), and fine fuels (<3" diameter), while reducing fire hazard. Because our current forest ecosystem has been influenced by management, particularly fire suppression and timber harvest, guidelines that reference pre-management or natural levels of snags and woody debris are inappropriate. We conducted an investigation into appropriate snag and woody debris levels for plant associations within the OECP LSR's (see Appendix D.). Our analysis focused on snags and woody debris sufficient to ensure that current productivity is maintained.

Fine fuels promote fire ignitions and will be limited to 12 tons/acre or less during fuel treatments. Material in the 3-16" size class contains a high proportion of fines, forms high concentrations in some stands, and often jackstraws and creates ladder fuels. Figure 11 shows appropriate ranges for 3-16" coarse woody debris. Non-true fir species will be targeted for retention to meet these tonnages. Non-true fir species decay more slowly and are currently less common than true fir in the LSR's. Woody debris greater than 16" in diameter does not contribute to fire hazard and is an important late

successional habitat component. Logs of this size are relatively scarce and fall through the canopy without creating ladder fuels. The >16" coarse woody debris component will be maintained during fuel treatment activities.

Plant Association	Coarse Woody Level	Snag Level	Snag Density
CW-C2-15	6.7-10.9 Tons/Acre	4.4-7.1 Tons/Acre	10 Snags/Acre
CW-H1-12	8.7-14.0 Tons/Acre	5.7-9.1 Tons/Acre	10 Snags/Acre
CR-S3-11	10.7-17.7 Tons/Acre	7.0-11.5 Tons/Acre	15 Snags/Acre
CR-G1-11/CR-S1-12	7.0-11.4 Tons/Acre	4.6-7.4 Tons/Acre	10 Snags/Acre

FIGURE 11. LEVELS OF SMALL DIAMETER COARSE WOODY DEBRIS AND SNAGS FOR ECOSYSTEM FUNCTION.

Snag density calculations were made based on average 12"-14" diameter true fir snags (Jahns et al., 1994). The levels shown in Figure 11 will be applied to the 3-16" size class. As with large coarse woody debris, snags >16" in diameter do not contribute to fire hazard and should be maintained to provide cavity nesting habitat and future large downed logs.

2. Late Successional Enhancement

As explained in the section on stand dynamics, successional trends do not necessarily promote development of late successional character. Opportunities may exist to create multi-canopied structure or reintroduce seral species through certain silvicultural manipulations. Additionally, enhancement treatments may be employed in plantations to correct effects of past actions.

Multiple Canopy Layers

Two treatments types, thinning and group regeneration, may be used to develop a multiple canopy structure out of a single-storied stand.

Commercial basal area thinning can encourage natural regeneration of true fir species when natural regeneration is limited because of dense (greater than 85%) canopy closure. By thinning to a canopy closure of 60%, sufficient incident light will allow for development of a new canopy layer of seedlings (Jahns, 1994). This prescription should be employed most frequently in Shasta red fir associations, in stands which have regenerated from stand-replacement fires.

Group selection harvests can also be used to create multiple canopies in a mosaic pattern. Size of groups will be 2 to 9 acres, to simulate the size of burns which occur under the current fire suppression regime. This treatment will also simulate openings caused by late stages of Armillaria infection. An added benefit will be the ability to introduce pine and Douglas-fir by planting them in the group selection units. This treatment may be employed in both white fir and Shasta red fir associations.

Plantation Management

Plantations on the Klamath Ranger District develop multi-storied structure in a shorter period of time than many plantations on the west side of the Cascades. By the time the planted trees reach 30 years of age, a carpet of true fir has naturally regenerated, creating the beginnings of a multiple-canopied stand. This phenomenon occurs naturally when planted trees provide a frost protection layer for true fir species. Consequently, traditional even-aged techniques produce a stand that will develop late successional characteristics quickly. Using lower planting densities and precommercial thinning could speed diameter growth. The target would be development of stands which attain 40% canopy closure at 11" diameter most quickly. In most plant associations, with proper density management regimes, these stand characteristics can be created 50 years after planting (Jahns, 1994). Precommercial thinning will be a necessary treatment to create such results in existing plantations, which were originally managed for different objectives. No plans are currently being made to initiate fertilization treatments to further speed plantation development.

Snags and Coarse Woody Debris

Other treatments to enhance late successional character in the OECP LSR's may include supplementing snag levels through blasting or tree topping, and supplementing coarse woody debris levels by dropping trees and leaving them. Snag creation may be used adjacent to existing clearcuts to mitigate the effect of loss of habitat for cavity nesting species. Because of the active insect/disease complex, most of the remainder of the LSR currently has an abundance of snags at present. Similarly, woody debris enhancements should be emphasized in plantations, where fuel reduction and site preparation treatments of the past have eliminated coarse woody reservoirs. Here, trees from the edge may be felled directionally into the plantation to speed recovery of the forest floor.

3. Commercial Treatment Summary

Interdisciplinary teams will use the summary chart in Figure 12 to develop stand treatment proposals. At a watershed scale, ID teams will evaluate the landscape context in which the stand treatments are proposed and make appropriate adjustments. For example, a thinning to reduce fire hazard may not be appropriate if the stand is isolated, occurs on a north slope, or has low risk of ignition. Similarly, treatments that create groups may not be appropriate if a large amount of open habitat already exists in the analysis area. Choosing between mutually exclusive treatments will be an IDT function as well.

Activities in the LSR will primarily be designed to lessen risk of loss of late successional values. Treatments will focus on fir engraver risk, western pine beetle risk, and fire hazard. Minor amounts of other risk treatments and enhancement treatments may occur. In many cases, stands at risk to fir engraver beetles are also at risk to western pine beetles and have high fire hazard and/or continuous ladder fuels. For this reason, estimated treatment acres in Figure 12 are not additive.

Currently, approximately 50% of white fir and mixed conifer stands in the LSR's are in an overstocked condition (based on site potential) and are at risk to

fir engraver attack. A disproportionate amount of the high risk stands are located in protected areas, such as riparian reserves, 100-acre unmapped LSR's, semiprimitive recreation areas, etc., and/or are difficult to access. For these reasons and landscape considerations, typically at least 50-60% of at risk stands in a watershed will not be proposed for fir engraver thinning treatments. Less than 5,000 acres (<9%) of the LSR's are expected to be treated during this decade.

Many stands at risk to fir engraver beetle also have large ponderosa pine or sugar pine at risk to western pine beetle. Culturing treatments may also occur in Shasta red fir stands where remnant pines are stressed by dense fir understories. Less than 5,000 acres at risk to western pine beetle are expected to be treated during this decade.

Fire hazard thinning will most frequently occur in white fir and mixed conifer stands in conjunction with fir engraver treatments. Less than 1,000 acres of this treatment are expected to occur.

B. Salvage

As discussed in Section VI., risk agents present on the Klamath Ranger District can kill trees at both stand and landscape levels. Such mortality as well as infrequent blow-down events can create stand replacement conditions where woody debris levels greatly exceed recommended amounts and impede the establishment of a new stand. Salvage of stands greater than 10 acres may be used to regulate the size and structure of pools of woody debris, and assist in prompt reforestation.

C. Hazard Trees

Removal of snags and logs may be necessary to reduce hazards to humans along roads and trails and in, or adjacent to, developed recreation areas. When materials must be removed from the site, as in a campground, a salvage sale is appropriate. Leaving cut material on site should be considered in other areas, such as along roads.

Treatment	Concentration Area	Triggers	Acres/Decade	Trend
Western Pine Beetle Culturing	Throughout LSR's Especially Eagle Mgmt.	PP + SP >20" Between 3 - 12 TPA and stand BA >150 sq. ft.	<5000	Decrease in future decades
Fir Engraver Thinning	White fir and Mixed Conifer Plant Associations	True fir BA> 60% and Ecoclass = CW and stand BA >maximum for plant association	<5000	Decrease in future decades
Mtn. Pine Beetle Thinning	Ponderosa and LPP plant associations	LPP + PP >5" DBH BA >50% and stand BA >150 sq. ft.	<800	Decrease in future decades
Fire Hazard Thinning	White fir and Mixed Conifer Plant Associations	Fuel model 10,11,12 canopy layers >1 and stand is overstocked	<1000	Increase in future decades
Armillaria Group Selection	Throughout LSR's	Armillaria in >25% of stand	<500	Increase in future decades
Mosaic Group Selection	Early Emphasis in Eagle Management	Single canopy and stand is overstocked	<100	Increase in future decades
Thinning to Create Structure	Red Fir Plant Associations	Single canopy and Canopy cover >85%	<100	Decrease in future decades

FIGURE 12. COMMERCIAL TREATMENT SUMMARY FOR THE OECP LSR'S.

PP = Ponderosa Pine; SP = Sugar Pine; LPP = Lodgepole Pine; BA = Basal Area; TPA = Trees Per Acre.

Acreages are not additive; one stand may have triggers for multiple prescriptions.

VIII. LANDSCAPE LEVEL CRITERIA FOR PROJECT DEVELOPMENT

In addition to site-specific criteria for selecting potential habitat treatments within forest stands in the OECP LSR's, landscape level criteria have been developed to describe desired conditions and relationships between stands (Morganti, 1993). It is recommended these criteria be applied to all project planning in the LSR's.

The primary objective of LSR's is to maintain and enhance habitat for late successional associated wildlife species. This includes, but is not limited to, habitat for the northern spotted owl. Because the spotted owl is recognized as a management indicator species for old growth habitats on the Winema National Forest and has been well-studied on the Klamath Ranger District, the following recommendations are based on our current understanding of the extent, distribution, and landscape patterns of spotted owl habitat. Presumably, these criteria will also benefit other late successional associated species.

There are three types of owl habitat in the LSR's: 1) habitat suitable for nesting, roosting, and foraging (NRF); 2) habitat suitable only for dispersal; and 3) minimally functional habitat (OPEN).

In the OECP LSR's, NRF habitat includes Shasta red fir and white fir plant communities with mid to late seral condition and greater than 55% canopy closure. Dispersal habitat occurs in white fir, Shasta red fir, lodgepole pine, or mountain hemlock/subalpine communities with mid to late seral conditions and a minimum of 40% canopy closure. Similar criteria have been used to map spotted owl habitat on the Ashland District. Open habitat is everything in the landscape other than the two habitat types described above: lakes, clearcuts, meadows, shrub fields, lava flows, etc.

In a study conducted on the Klamath Ranger District, Morganti (1993) noted the need for high proportions and large patch sizes of NRF habitat. High structural complexity in the horizontal and vertical dimensions and high landscape continuity of NRF habitat also appear to be important to spotted owls. These indicators collectively point toward the importance of a dominant **"matrix"** of suitable spotted owl habitat (Forman and Godron, 1986). This condition currently exists in the OECP LSR's but is less complete in parts of the western half of LSR R0227.

Harris (1984) called large and highly connected habitat masses **"continental habitat masses"**. These can serve as a large resource pool to support ecological functions and recolonize disturbed sites with remnant biological legacies (Franklin, 1988). The archipelago principle suggested by Patton (1992) and Harris (1984) also supports the idea of significant ecological processes occurring via this continental habitat mass. The matrix of suitable habitat needed by spotted owls in the high Cascades serves as a continental mass of habitat in structure and function.

In order to avoid confusing the ecologically dominant "matrix" theorized by Forman and Godron with "matrix lands" outside of the LSR's, as designated by the ROD, this document will use the term **"fabric of habitat"** or simply **"fabric"** to describe the habitat matrix.

A. Extent, Distribution, and Landscape Patterns of the LSR's

1. Spotted Owl Habitat Within the LSR's

Currently, 46% of the three LSR's provides suitable NRF habitat for the spotted owl (see Map O). As a whole, the LSR's have relatively large masses of NRF habitat compared with adjacent matrix lands. In LSR R0227, sizable blocks of habitat are present in the westernmost portion on the Ashland District, in the Lake of the Woods Basin, and on the slopes of Pelican Butte. LSR R0228 in the Sevenmile drainage also has a relatively large block of NRF habitat. NRF habitat connectivity is generally good throughout all three LSR's and is augmented by adjacent wilderness habitat.

At the crest of the Cascades, connection of the Lake of the Woods habitat mass to the western portion of LSR R0227 occurs north of Brown Mountain, extending into Sky Lakes Wilderness on the lower slopes of Mt. McLoughlin. South of Brown Mountain, east-west connectivity is limited primarily to riparian corridors, as a result of extensive timber harvest on the Ashland District in this area. Much of the Brown Mountain Semiprimitive Recreation Area consists of lava flows and is incapable of producing NRF.

Dispersal habitat is generally abundant. It covers roughly 70% of the three LSR's and is well distributed between the LSR's and through wilderness (Map P). Approximately 57% of the matrix lands on the Klamath District provide dispersal habitat. NRF habitat meets dispersal habitat requirements, and is included in the dispersal habitat figures.

The remainder of the LSR's, 30%, does not meet suitable habitat requirements and is considered to be minimally functional (OPEN). The western portion of LSR R0227 has a higher amount of OPEN habitat than the OECP LSR's, as a result of more regeneration harvest and a higher amount of non-forest.

2. Connectivity Between LSR's

NRF habitat is relatively highly connected at the landscape level on the Klamath Ranger District from north to the south, between and within the LSR's. Only small gaps appear in this landscape-scaled fabric of habitat, although substantial holes exist. The biggest gaps (a few hundred feet wide) occur in the Threemile, Sevenmile, and Annie Creek watersheds. While wilderness contributes to connectivity of NRF habitat between the LSR's, generally, riparian reserves do not. This is because the major creeks flow east-west from the crest of the Cascades to Upper Klamath Lake and not between the LSR's.

3. Connectivity to Crater Lake National Park

LSR R0229 appears to be weakly connected through NRF habitat to Crater Lake National Park to the north. Lodgepole pine stands naturally occur in the cold air drainages and basins of this area, limiting NRF capability. Current mapping indicates some of the lower elevation linkages have been severed by past harvest. Many created openings are present in the Annie Creek and Goosenest areas, and fragmentation predominates outside the LSR adjacent to the Park in the northernmost portions of the District. Dispersal habitat is strongly connected to the Park through subalpine and lodgepole pine plant communities in Skylakes Wilderness.

4. Connectivity to the South

NRF habitat in the southern portion of the Klamath Ranger District is moderately fragmented. Relatively large plantations with simple shapes are located in this area, particularly in blocks of private land. Continuity of NRF habitat between LSR R0227 and LSR R0228 is maintained in through the southwest corner of Mountain Lakes Wilderness. South of the Klamath Ranger District, areas owned by US Timberlands and lands administered by the BLM are highly fragmented, caused by both natural conditions and past timber harvesting. Owl pairs are present on BLM lands in this area, but habitat conditions appear less suitable than on the Klamath Ranger District.

5. Eastern/Western Boundaries

Upper Klamath Lake, Agency Lake, and their associated pastures and wetlands form the eastern boundary of spotted owl habitat in this area. The western boundary of R0227 occurs at the edge of the Ashland District boundary, in plant associations which are incapable of producing spotted owl habitat.

B. Landscape Recommendations

Maintaining the existing functioning of the continental habitat mass for spotted owls is the primary consideration in the following landscape-scale recommendations for projects conducted in the three LSR's. Recommendations are based on the results of a spotted owl habitat analysis conducted on the Klamath Ranger District. These recommendations may not be wholly applicable to LSR R0227 in the western province, although it is likely that managing for high levels and connectivity of NRF habitat in this area, as well, will benefit late successional species. Recommendations for the western province area will be discussed further in the forthcoming South Cascades LSR Assessment.

1) The goal of management in the OECP LSR's should be to promote retention and development of NRF habitat, such that at least 50% of the LSR's are maintained in that condition. Analysis on the District indicates that spotted owls select territories which are comprised of 48-64% NRF habitat more frequently than territories with greater or lesser amounts of NRF (Morganti, 1993). This is despite the fact that fewer territories with 48-64% NRF are available in the landscape. To maximize use, NRF habitat should also be distributed as evenly as possible throughout the LSR's. Because the OECP LSR's currently have less than 50% NRF habitat, this recommendation represents a long-term goal. As stated in Section IV-E., approximately 25% of the OECP LSR's are either incapable of becoming NRF or are unsustainable; this limits the upper level of NRF which can be attained.

2) Projects that create openings, such as regeneration treatments, should be limited such that no more than 25% of the LSR's are in an OPEN condition at one time. Owls on the Klamath Ranger District appear to select territories with 16-32% OPEN habitat more frequently than territories with greater or lesser amounts of OPEN habitat, and more frequently than the availability of such conditions in the landscape.

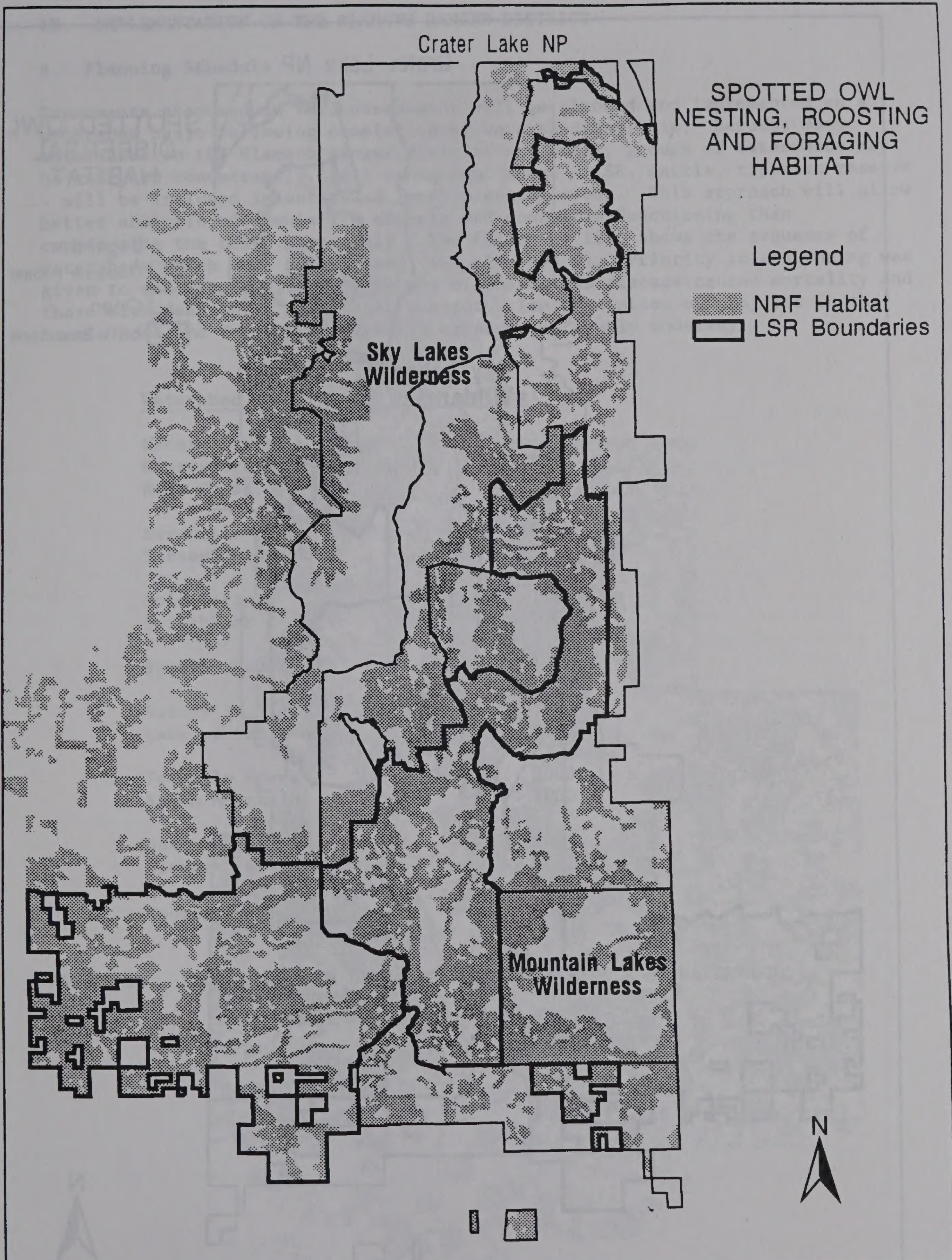
3) At least 50% of each 2,955-acre spotted owl median home range associated with an activity center in the LSR should be maintained in NRF habitat, for the reasons stated under the first recommendation.

4) A relatively continuous (i.e., highly connected) fabric of suitable NRF habitat should be provided at the scale of the District, although it may have "holes" and small gaps in it. High connectivity between large masses or patches of NRF habitat should be maintained, including the continuity of LSR R0227 onto the Ashland District. Projects which sever linkages between well-connected stands of NRF habitat should be avoided. Enhancement treatments which promote development of NRF habitat between severed linkages should be encouraged.

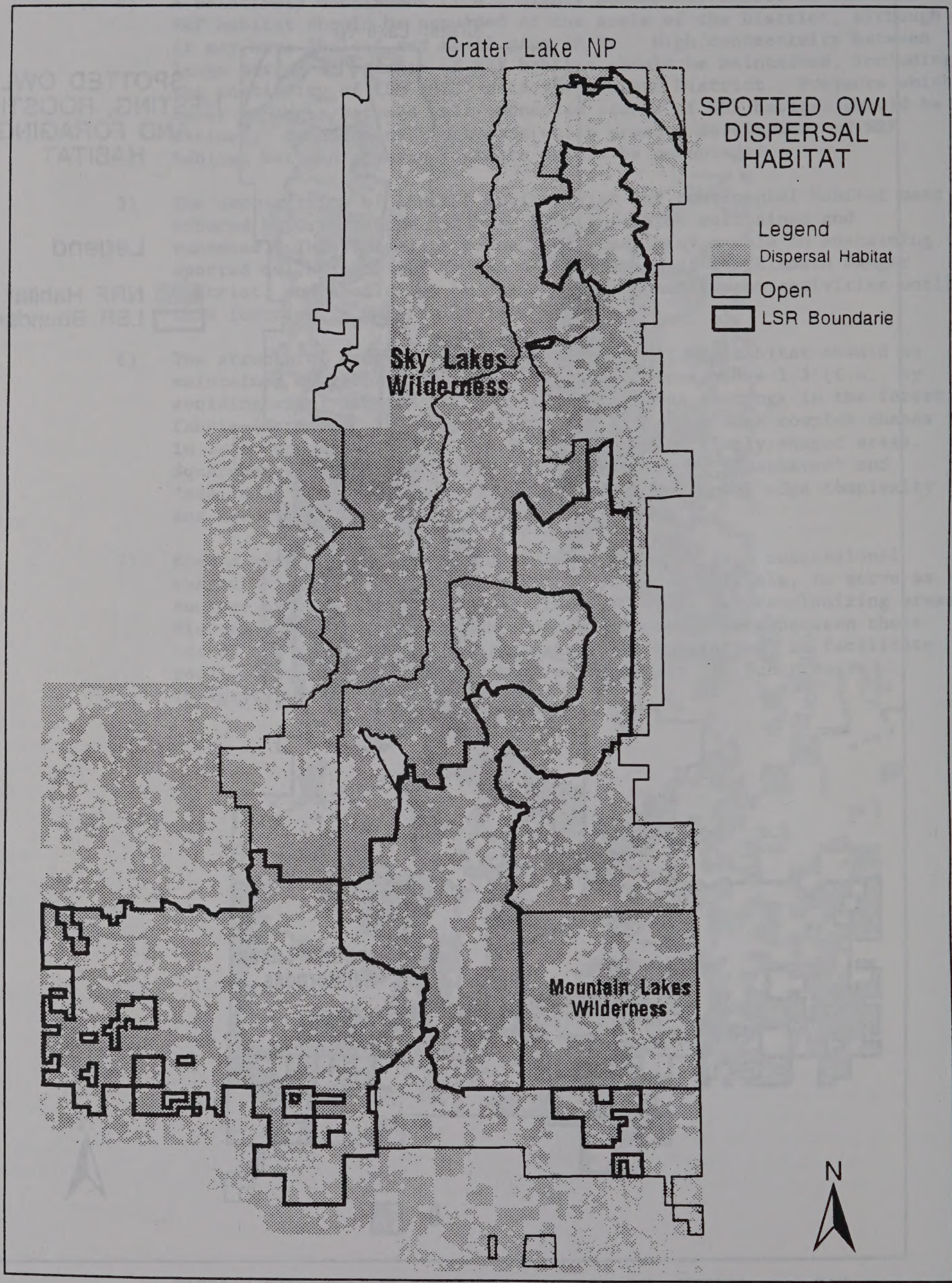
5) The connectivity of LSR NRF habitat with the continental habitat mass offered by Crater Lake National Park should be maintained and enhanced. This landscape connectivity may play a role in sustaining spotted owl NRF habitat in the northern part of the Klamath Ranger District, and should not be interrupted by management activities until this function is more fully understood.

6) The structural complexity around the edges of NRF habitat should be maintained by keeping fractal dimension indices above 1.3 (i.e., by avoiding simply-shaped polygons) when creating openings in the forest fabric (Morganti, 1993). Spotted owls appear to seek complex shapes in late successional habitat and tend to avoid simply-shaped areas. Square or rectangular created openings should be "feathered" and "scalloped" to increase both vertical and horizontal edge complexity and associated microhabitat diversity.

7) Stands within the LSR's which currently exhibit late successional characteristics should be maintained, whenever possible, to serve as sources of biological legacies (Franklin, 1988) for recolonizing areas disturbed by natural or human processes. Connections between these stands and adjoining NRF habitat should be maintained, to facilitate recolonization of disturbed areas and maintain the functional integrity of the habitat fabric.



MAP O. SPOTTED OWL NESTING, ROOSTING, AND FORAGING HABITAT.



MAP P. SPOTTED OWL DISPERSAL HABITAT.

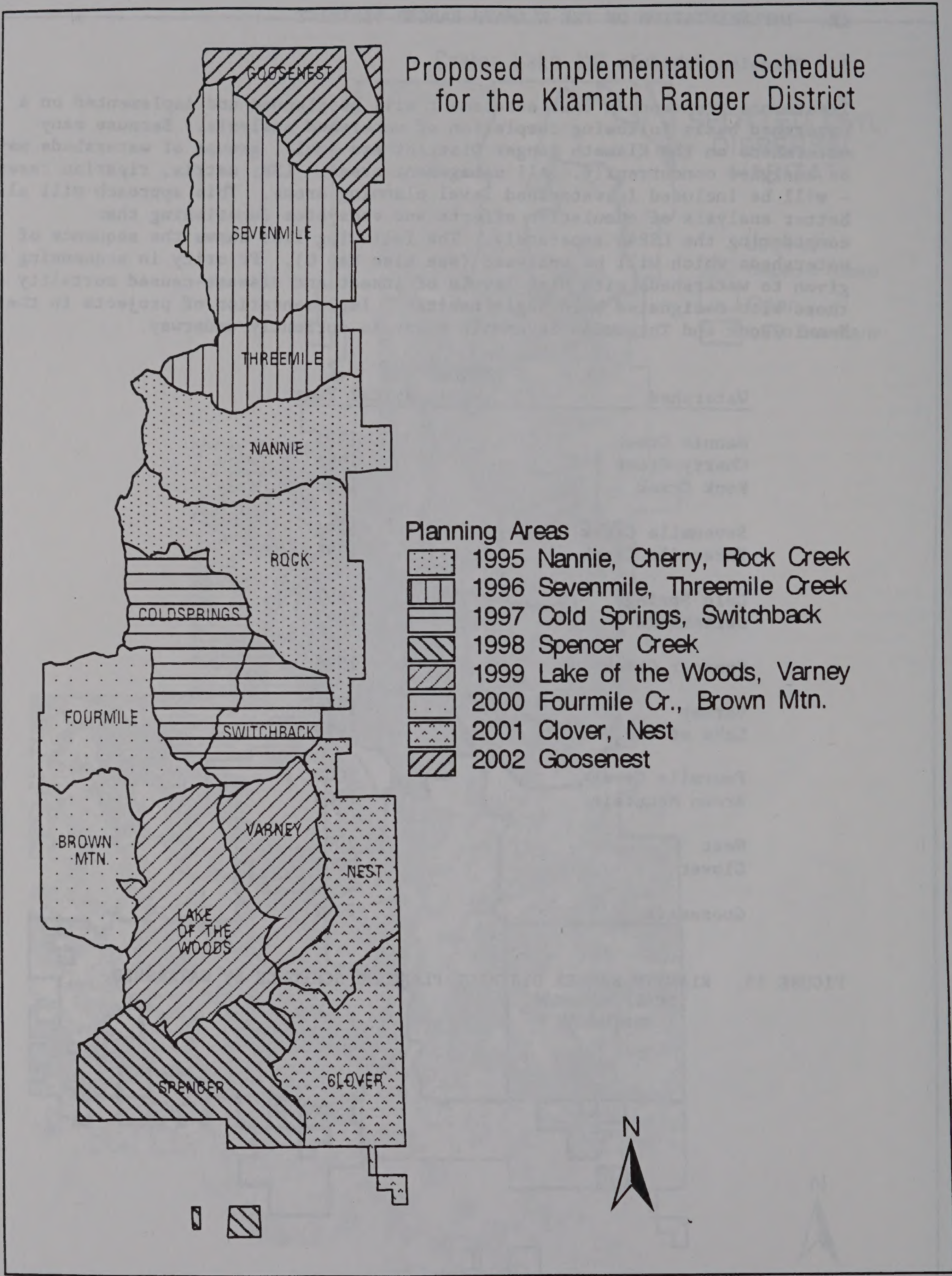
IX. IMPLEMENTATION ON THE KLAMATH RANGER DISTRICT

A. Planning Schedule

Treatments proposed in this assessment will be planned and implemented on a watershed basis following completion of watershed analysis. Because many watersheds on the Klamath Ranger District are small, groups of watersheds may be analyzed concurrently. All management areas - LSR, matrix, riparian reserve - will be included in watershed level planning areas. This approach will allow better analysis of cumulative effects and ecosystem functioning than considering the LSR's separately. The following list shows the sequence of watersheds which will be analyzed (see also Map Q). Priority in sequencing was given to watersheds with high levels of insect and disease-caused mortality and those with designated bald eagle habitat. Implementation of projects in the Nannie/Rock and Threemile/Sevenmile areas is currently underway.

Watershed	Fiscal Year
Nannie Creek	1995
Cherry Creek	1995
Rock Creek	1995
Sevenmile Creek	1996
Threemile Creek	1996
Cold Springs	1997
Switchback	1997
Spencer Creek	1998
Varney	1999
Lake of the Woods	1999
Fourmile Creek	2000
Brown Mountain	2000
Nest	2001
Clover	2001
Goosenest	2002

FIGURE 13. KLAMATH RANGER DISTRICT PLANNING SCHEDULE BY WATERSHED.



MAP Q. PROPOSED IMPLEMENTATION SCHEDULE FOR THE KLAMATH RANGER DISTRICT.

B. Matrix of Interactions

Each species has a unique set of habitat requirements for completing its life history (Patton, 1992). This makes the assessment of habitat needs for numerous species extremely complex. To address this complexity, a "matrix of interactions" (Diaz and Apostol, 1992) was developed on the Klamath Ranger District. Our matrix of interactions is a modified version of the wildlife habitat model used by the Blue Mountain analysis team (Thomas et al., 1979).

The tool was designed to meet the following objectives:

1) Can be applied to a variety of species and habitat types.
2) Can be used in a system where uneven-aged management and past harvesting makes the description of seral stages difficult.
3) Allows for modeling of the effects of alternative management actions on species' habitats.
4) Can predict habitat locations for more efficient monitoring and inventory.
5) Is compatible with relational databases and Pacific Meridian Resources (PMR) satellite data.
6) Is compatible with existing analysis and management processes.
7) Is scientifically credible.

1. Applications

The matrix of interactions has been automated and applied to Klamath Ranger District planning efforts, including watershed analysis and project planning. It has been used to assess the likelihood of species occurrence, past and present habitat conditions, and effects of alternative management scenarios. The matrix can be used to map potential habitat and prioritize areas for monitoring and surveying. Initial attempts to apply the matrix have indicated the importance of ground truthing and/or having survey data available to fine tune the model.

2. The Matrix

Each species considered is given a column in the matrix of interactions (Figure 14.). A "species" might be fire, root rot, mountain pine beetle, matsutake mushrooms, spotted owl, or any other energy flow phenomena. Each potential habitat type (e.g., nesting habitat) has a row for each species. Each element of the matrix is an alphanumeric symbol (A1, B4, etc.), which represents a structural definition of habitat type and can be detailed on a separate data card for each species. Each element can be a relational database query alone, or a database query combined with a GIS mapping scheme. Each "0" represents a habitat type that is not present on the District, or does not have meaning for that species.

The number of habitat types used in a particular analysis is "n". The value of "n" in an analysis is determined by the **analytical resolution** desired (Morganti, 1993) and can vary from analysis to analysis, depending on the information and degree of detail desired. One analysis might look at 3 habitat types for a species, another 7 habitat types for the same species. Results may vary between the two analyses because of the analytical resolution used.

	Species 1	Species 2	Species 3	Species 4	....	Species X
Type n Primary habitat e.g. nesting	A_n	B_n	C_n	D_n	......	X_n
Type n-1 secondary e.g. roosting	A_{n-1}	B_{n-1}	0	0	......	$X_{(n-1)}$
Type n-2 e.g. dispersal & migration	A_{n-2}	0	C_{n-1}	0	......	$X_{(n-2)}$
Type n-3 e.g. thermal	A_{n-3}	0	C_{n-2}	0	......	$X_{(n-3)}$
Type n-4 e.g. hiding	0	0	C_{n-3}	0	......	$X_{(n-4)}$
Type n-5 e.g. foraging	A_{n-4}	B_{n-2}	0	D_{n-2}	......	$X_{(n-5)}$
.	.	.	.	.	.	
Type n-(n-1) non-functional	A_1	B_1	C_1	D_1	......	X_1
No Information	0	0	0	0	0	0

FIGURE 14. MATRIX OF INTERACTIONS BETWEEN ECOSYSTEM STRUCTURE AND FUNCTION WITH RESPECT TO WILDLIFE HABITAT.

Detail resolution is the amount of detail used to define each habitat type in the matrix of interactions (Morganti, 1993). A habitat type based on only canopy closure has lower detail resolution than a habitat type based on canopy closure, number of snags, downed trees, etc.

3. Example

A portion of the District matrix of interactions is shown in Figure 15.

Spotted Owl	Bald Eagle	Yellow Rail
A_3	B_5	Y_2
A_2	B_4	Y_1
A_1	B_3	Y_0
A_0	B_2	
	B_1	
	B_0	

A_3 - Spotted Owl Nesting/Roosting/Foraging Habitat

A_2 = Spotted Owl Dispersal Habitat

A_1 = Non-functional Spotted Owl Habitat

A_0 = No Information

B_5 - Bald Eagle Nesting Habitat

B_4 - Bald Eagle Nest Replacement Habitat

B_3 - Bald Eagle Winter Roosting Habitat

B_2 = Bald Eagle Feeding Habitat

B_1 = Non-functional Habitat

B_0 = No Information

Y_2 = Yellow Rail Breeding/Feeding Habitat

Y_1 - Non-functional Habitat

Y_0 = No information

FIGURE 15. SAMPLE PORTION OF THE MATRIX OF INTERACTIONS.

Each matrix element (A_3, B_3, Y_2, etc.) defines a database query. For example, A_3, spotted owl nesting/roosting/foraging habitat, can be described by a PMR query for tree species, canopy closure, and size/structure. When the PMR database is queried, a map showing potential NRF habitat for the spotted owl can be created. Other databases can also be used.

C. Ongoing Activities and Uses in the OECP LSR's.

Portions of the OECP LSR's are allocated to ongoing activities and pre-existing multiple uses. Many of these have minimal effects on LSR objectives. Examples are discussed below.

1. Genetic Improvement Program

Two seed orchards and a western larch provenance test are located within the OECP LSR's. The seed orchards should be maintained to ensure a seed supply for reforestation and the provenance test continued. Select trees have also been chosen throughout the LSR's and should be maintained to ensure a large genetic sample for future reforestation efforts.

2. Livestock Grazing

Portions of LSR R0227 and LSR R0228 are included in the Buck Range Allotment (Map E). The effects of grazing will be analyzed in conjunction with future range project decisions or Allotment Management Plans. It is likely that effects of concern in this allotment will be related to riparian resources; cattle grazing is unlikely to have significant impacts on late seral forest.

3. Recreation

As stated in Section II-F, many recreation developments occur within the OECP LSR's. These range from snowmobile, cross-country ski, and mountain bike trails to three developed campgrounds and day use areas, recreation residences, and three organizational camps. There are not likely to be any additional effects from these existing developments on late successional character; however, many must be reviewed for consistency with the Aquatic Conservation Strategy objectives. Maintenance and administration of these facilities will be ongoing.

Any potential effects of the proposed Pelican Butte ski hill development will be analyzed during the EIS process.

4. Special Forest Products

Collection of special forest products in the OECP LSR's will continue at low levels. Mushrooms and personal use Christmas trees will continue to be the main products. Neither removal of morel mushrooms (which are associated with disturbance rather than late successional forest), or removal of precommercial trees will affect late successional objectives. Commercial Christmas tree sales may also occur. Requests for other special forest products are expected to be infrequent and will be evaluated on a case-by-case basis.

X. MONITORING PLAN

Monitoring should occur at both the individual project level and at a broader scale throughout the OECP LSR's. In the future, additional monitoring established at the Regional level may also be conducted on the District. Future Regional monitoring plans may supercede this plan.

A. Project Level

Monitoring at the project level should be used to answer the question "are the guidelines established in this assessment and other management recommendations and requirements correctly applied and followed?" (implementation monitoring). These include:

1) Standards and Guidelines in the ROD.
2) Standards and Guidelines in the Forest Plan.
3) Management concerns raised during Watershed Analysis.
4) Mitigation measures included in the project NEPA analysis.
5) Treatment recommendations in the LSR Assessment.

Key items to consider include:

1) Timber harvest is consistent with standards and guidelines and with Regional Ecosystem Office review requirements.
2) Other management activities are consistent with standards and guidelines.
3) Management activities are consistent with the LSR Assessment.

An example of a process which could be used to monitor timber sales is shown below. Similar processes could be used for other projects. See also Post-fire Evaluations in Section XI.

The interdisciplinary team will review NEPA documents for correct application of standards and guidelines, LSR Assessment recommendations, and other management recommendations and requirements. The team will develop a monitoring plan/schedule.

The team leader will ensure standards and guidelines and mitigation measures are included in the timber sale contract.

The prescription for each unit will be explained to the presale crew in the field by the silviculturist, and units will be reviewed by the silviculturist and other resource specialists after marking.

During logging, the silviculturist, sale administrator, and other resource specialists will visit units to ensure the operation is occurring as planned.

After harvest, the silviculturist and fuels specialist will assess the need for postsale work to meet prescriptive intent. Selected units will be monitored for coarse woody debris levels.

After implementation is complete, the interdisciplinary team will

reconvene and review harvested units to determine whether objectives were achieved. The team will complete a monitoring report to be included in the project file.

A formal postsale exam will also be conducted to quantitatively assess stand conditions after implementation.

B. LSR Scale Monitoring

Broader scale monitoring should be used to determine whether treatments proposed in this assessment are meeting desired future conditions in the OECP LSR's and the objectives of standards and guidelines (effectiveness monitoring). The primary questions should be:

1) Did silvicultural treatments benefit the creation and maintenance of late successional conditions?
2) Did silvicultural and fuels treatments reduce risk of loss of late successional habitat from insects, disease, and wildfire?
3) Are desired habitat conditions for the spotted owl and bald eagle maintained where adequate, and restored where inadequate?
4) Are landscape level recommendations being met?
5) Are habitat conditions for other late successional forest associated species maintained where adequate, and restored where inadequate?

Key items to consider include the seven characteristics of late seral forests discussed previously in Section IV. E. and the seven landscape recommendations discussed in Section VIII.

Examples of specific monitoring activities are listed below.

Stand examinations will be performed approximately every 10 years to monitor the condition of the forest, growth rates, mortality rates, snag levels, and fuel levels.

Insect and disease monitoring flights will occur annually.

Forest inventories will be conducted every decade to assess changes at the Forest level.

Spotted owl nest surveys will be conducted to determine the effects of silvicultural treatments in the LSR's.

C. Other Monitoring

Monitoring to assess the accuracy of underlying management assumptions (validation monitoring) should be conducted in partnership with research and as funds become available. Three projects are listed below:

An administrative study with Oregon State University is looking at changes in the rates of Armillaria root rot spread under different silvicultural treatments.

A fire history study is being conducted in the Cherry, Nannie, and Threemile watersheds under an agreement with PNW.

A study of coarse woody debris decomposition rates in different plant associations has been completed under an agreement with PNW.

D. Adaptive Management

New information gained through District monitoring and outside sources should be evaluated to determine whether changes or adjustments should be made to the treatments and recommendations proposed in this assessment, including the monitoring plan. The goal of changes or adjustments to this assessment should be to better meet the objectives of the standards and guidelines in the ROD.

E. Use of Existing Data

Because implementation of risk reduction and enhancement projects recommended in this assessment is currently underway in the OECP LSR's, monitoring of these treatments has not yet been completed. However, the Klamath Ranger District has conducted postsale exams to determine the results of similar silvicultural treatments initiated prior to signing of the ROD. Appendix E shows measurements of key habitat features, such as multiple canopies, canopy closure, large trees, and snags after harvest treatments. The data show that NRF habitat can be maintained following harvest. In units where canopy closures fall short of the objectives for LSR management, the data will be used to adjust future silvicultural prescriptions.

The Klamath Ranger District also has existing spotted owl demographic data collected during 1990-1996. This data was used in conjunction with the postsale exam data mentioned above to investigate the effects of the harvest treatments on spotted owl nesting and reproduction. Two territories were found which contained recent harvest treatments which maintained NRF habitat after harvest. One of the two pairs has successfully reproduced since the harvest was completed. However, there is too little data, and reproductive success is too variable to draw any significant conclusions.

Of the 53 spotted owl territories on the Klamath Ranger District, 51 have had measurable harvest activities within their home range within the last 25 years. The two territories with no harvest activity are located in Sky Lakes Wilderness in marginal habitat. Neither of those wilderness pairs has reproduced in the last ten years, although they were not monitored every year during that period. Reproduction was documented in 30 territories following harvest treatments, indicating owls will still use sites after logging occurs.

XI. FIRE MANAGEMENT PLAN

The goal of the Fire Management Plan for the OECP LSR's is to halt or delay fire spread in order to maintain each fire within predetermined parameters, while producing the least possible impact on the resource being protected. These parameters are provided by the initial attack Incident Commander's size-up of the fire or by the Escaped Fire Situation Analysis.

Safety is the highest priority for suppression efforts. All actions will be anchored to the standard fire orders and the "watch out" situations. Safety will be the responsibility of everyone involved.

Guidelines for low impact fire suppression are as follows:

For hot-line and ground fuels, allow fire to burn to natural barriers. Use "cold trail", wet line, or a combination thereof, when appropriate. If constructed fireline is necessary, due to fire behavior and/or fire potential, construct the line wide and deep enough to check fire spread. Use burning-out as a fire suppression tool. Minimize bucking and cutting of trees to establish fireline; build lines around coarse woody debris. Utilize dozers only on less than 30% slope. Whenever possible, utilize excavators such as rubber-tired skidders, rather than tracked vehicles. Use a high pressured sprayer on all machinery to prevent spread of noxious weeds.

For hot-line involving aerial fuels, remove only the limbs that have potential for spreading fire outside the fireline. Before felling trees, consider allowing ignited trees or snags to burn out. Safety measures and communication with suppression forces are essential if this is allowed to occur. Identify these hazard trees with flagging and/or a lookout. If these burning trees or snags pose a serious threat of spreading and igniting fire elsewhere, extinguish fire with water or dirt whenever possible. If they are causing safety and/or serious control problems, then felling is permissible. If trees have to be cut, align saw cuts to minimize visual impacts from more heavily-traveled corridors. Felling of these trees should be the last resort. Surviving trees that have a defect caused by fire can provide valuable wildlife habitat. Consequently, all standing live trees should be retained.

Maps for known spotted owl activity centers and bald eagle nesting areas are available on the District. Minimum impact suppression techniques will be used in all these sites. Aviation and suppression activities will be monitored closely for any environmental effects to these areas.

Guidelines for mop-up of ground fuels will include a minimum amount of spading of hot areas. "Cold trail" charred logs near the fireline; extinguish large woody debris and duff as rapidly as possible. Instead of bucking up large logs, attempt to roll the logs to extinguish the fire. Return the logs to their original position after checking to make sure the area is out. When possible, utilize fold-a-tanks, instead of draft pumping from creeks. If pumps are utilized, use absorbent pads underneath them. Utilize infrared detection to locate spots; this will assist in mop up, and will reduce the risk of the fire re-igniting and spreading.

To mop up aerial fuels, remove or limb only those fuels which, if ignited, have the potential to spread fire outside the fireline. If burning trees or snags pose a serious threat of spreading fire brands, extinguish fire with water or dirt whenever possible. Ensure safety of suppression crews at all times. If a snag or green tree cannot be extinguished and is a control problem, a snag/tree can be felled. Align saw cuts to minimize visual impacts, cover stumps with dirt after felling.

A. Logistics

Logistics in the Late Successional Reserves include incident bases, helispots, and heliports. Interdisciplinary teams will propose sites for these facilities, on a watershed basis. Incident bases will not be located within Riparian Reserves. Evaluate the use of short-term impact camps, such as spike or coyote camps, versus the use of longer-term, higher impact incident base camps. Use existing campsites, such as Fourmile Rock Quarry, whenever possible. New site locations should be on naturally-draining areas, such as sites with rocky or sandy soils, or in natural openings surrounded by heavy timber. Avoid locating camps in meadows. When laying out the camp, define cooking, sleeping, latrine, and water supply locations to minimize the number of trails in camp, thus reducing compaction to the site. Adequately mark trails. Ensure that crews do not clear vegetation or dig trenches in sleeping areas. Use fabric ground cloths for protection in high use areas, such as around the cooking facilities. Use commercial portable toilet facilities. Constantly evaluate the impacts, both short and long term, of the camp. Include rehabilitation of campsites in the rehabilitation plan.

B. Aviation Management

One of the goals for Late Successional Reserve managers is to minimize the disturbance caused by air operations during an incident.

Aviation guidelines for Late Successional Reserves stress use of the minimum size helicopter that can do the job and still meet the intended suppression strategy and objectives. If possible, utilize long-line remote hooks, instead of constructing helispots. Do not construct helibases or helispots within Riparian Reserves. Preplanned helispots and helibases will be determined by an interdisciplinary team on a watershed basis. If an area is needed that is not included in the preplanned map, consider utilizing natural openings or already-impacted areas, such as landings for logging operations, but avoid areas with high visitor use.

During initial attack, fire managers must weigh the use of retardant versus the probability of initial attack crews being able to successfully control or contain a wildfire. If a determination is made that retardant will prevent a larger and more damaging wildfire, then retardant may be used. Retardant or foam will not be dropped on surface waters, in riparian reserves, in the Lake of the Woods drainage basin, or on spotted owl and bald eagle nests.

C. Fire Rehabilitation

Rehabilitation will be designed to restore conditions of late-successional and old-growth ecosystems. Rehabilitation is a critical need, arising from the impacts associated with fire suppression and the logistics that support it.

The process of constructing control lines, transporting personnel and materials, providing food and shelter for personnel, and other suppression activities will significantly impact sensitive resources, regardless of the mitigating measures described above. During rehabilitation efforts, a resource advisor with expertise on Late Successional Reserves will be available.

D. Rehabilitation Guidelines

Pick up and remove all flagging, garbage, litter, and equipment. Dispose of all trash appropriately. Discourage the use of lines constructed for fire suppression as trails, by covering with brush, limbs, small diameter poles, and rotten logs in a naturally-appearing arrangement. Replace dug-out soil and/or duff and obliterate any berms created during suppression efforts. If control lines have been constructed on slopes greater than 5%, build waterbars. Following is a guide for construction of these waterbars:

Trail Percent Grade	Maximum Spacing Ft.
5-15	150
16-25	100
25-65	50
65+	25

Cover these control lines with coarse woody debris.

Where soil has been compacted from construction of incident base camps, helibases, etc., consider sub-soiling and scattering rocks and dead branches, and/or replanting the area with native plants.

E. Post-fire Evaluations

Post-fire evaluation is important for identifying areas that need improvement, formulating different strategies to add to the fire management plan, and assisting in producing quality work in the future. As part of this evaluation, resource advisors and Interdisciplinary Team members will evaluate this plan to ensure that the intent of the Standards and Guidelines in the ROD have been met. Post-fire evaluation will consist of data collection, documentation, and making recommendations. The evaluation will occur prior to the departure of the overhead team, so that a copy can be placed in the final fire package. A copy of the evaluation will be given directly to the line officer.

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APPENDIX A. SPOTTED OWL NESTING HABITAT ANALYSIS FOR KLAMATH RANGER DISTRICT.

Prior to the ROD signature, we collected information on six stand structure parameters within 100-acre core areas of known spotted owl nest sites. We compared this information to general landscape conditions.

Using Region 6 stand exam protocol, data was collected on 100-acre core areas for 30 spotted owl nest stands. Walk-thru exams were done on 486 stands that represent 15,104 acres of general landscape, including the LSR. The landscape sample area is the middle and southern portion of Lake of the Woods Basin area. The following charts label the owl nest data as "owl" and the general landscape data as "non-owl".

Normalized frequency distribution graphs were used to compare the six parameters in owl and non-owl stands. The dark columns represent the percent of acreage in the sampled general landscape, and the shaded columns, the percentage of acreage in spotted owl nest stands. The columns are paired by the numerical groupings for each parameter. The graphs indicate the range of conditions selected by spotted owls. The graphs also indicate owl preference for a condition above its availability in the general landscape. When nest stands were selected by owls without regard to a parameter, the owl and non-owl column are roughly the same height. Where owls tended to prefer a given condition, the owl column is greater than the non-owl column.

The 6 parameters are discussed below:

1) Canopy Layers. Measuring canopy layers is a subjective call by the examiner; the Region 6 Timber Stand Exam definition was used. No nest trees were in single-storied stands; all appeared in multi-canopy stands. Approximately 25% of the general landscape has single story canopy structure. See Figure A-1.

2) Canopy Closure. Percent crown closure was measured to the nearest 10%, using a densiometer. Nest stands ranged from 50% to 90% canopy closure. There is a strong preference for 60% and 70% crown closure, compared to the general landscape. See Figure A-2.

3) Remnant Trees. Remnant trees refer to Douglas-fir, ponderosa pine, and sugar pine that are greater than 25" in diameter, tallied by trees per acre. The tree size was chosen for ease of tracking stand exam information, and the 25" diameter is not meant to be a future guideline. Owls showed a preference for stands with 1-10 remnant trees per acre, compared to what was available in the general landscape. See Figure A-3.

4) Snags. All tree species of snags greater than 22" in diameter were tallied by snags per acre. The snag size was chosen for ease of tracking stand exam information, and the 22" diameter is not meant to be a future guideline. Even though 56% of nest stands had less than five snags per acre, owls showed a strong preference for six and greater snags per acre, compared to availability in the general landscape. See Figure A-4.

5) Coarse Woody Debris. Coarse woody debris tons per acre was subjectively determined by the examiner, using photo series for quantifying natural forest residues (Maxwell, 1976 and 1980). The general landscape had two peaks, one at 10.1 to 15 tons per acre and the other at 20.1 to 25 tons per acre. Nest stands ranged from 8 to 32 tons per acre. There was no indication of a strong preference by owls. See Figure A-5.

6) Down Logs. The number of down logs greater than 20" in diameter was subjectively determined by the examiner using the photo series for quantifying natural forest residues. The 20" log size is the delineation used in the photo series classifications. Nest stands ranged from 0 to 12 tons per acre of down logs greater than 20". Owls preferred stands with greater than 2 tons per acre. See Figure A-6.

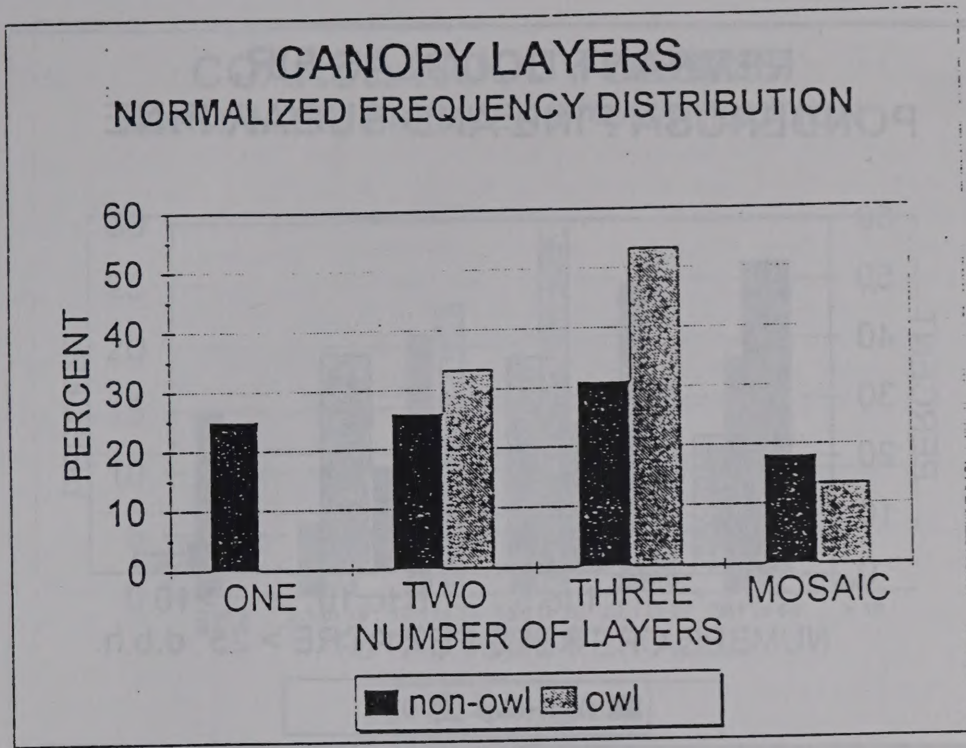

Figure A-1. Canopy Layers.

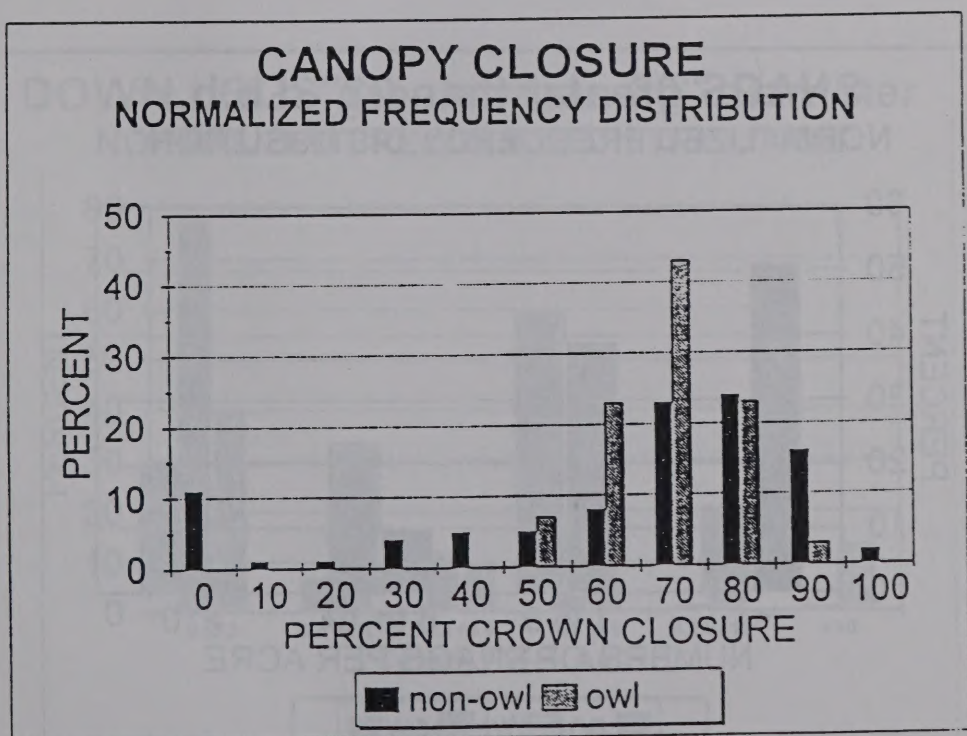

Figure A-2. Canopy Closure.

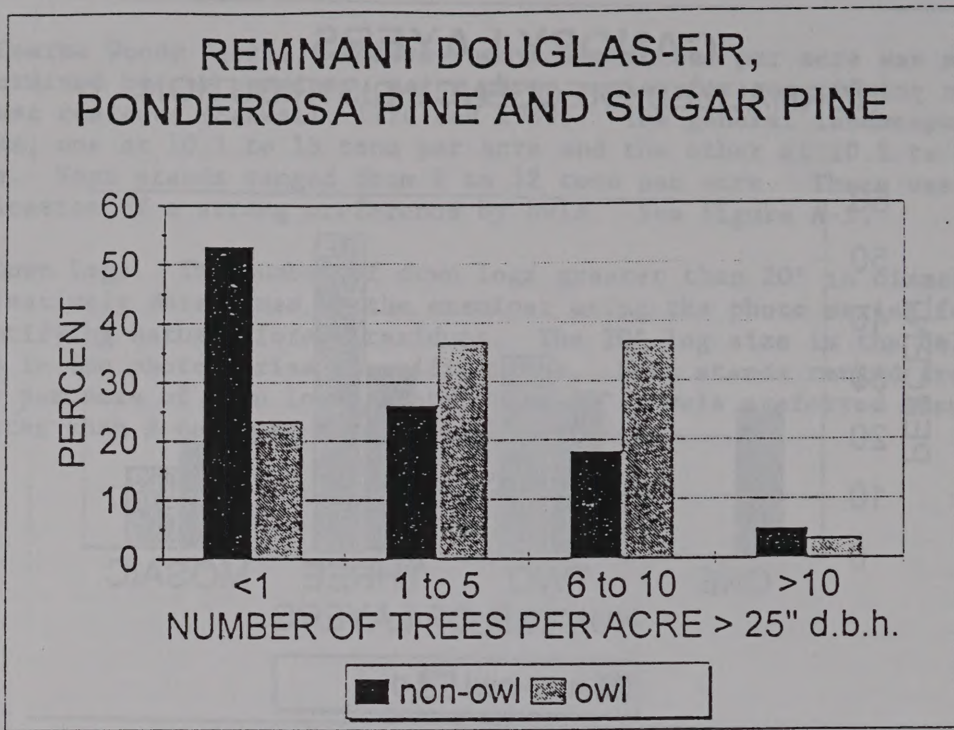

Figure A-3. Remnant Douglas-fir, ponderosa pine and sugar pine.

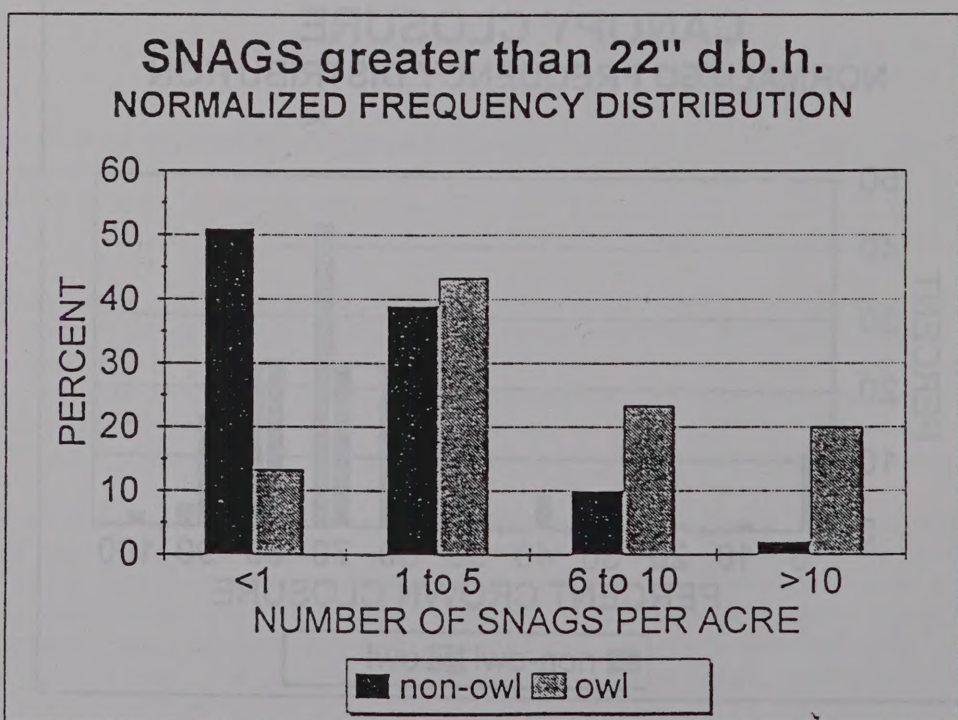

Figure A-4. Snags greater than 22 inches d.b.h.

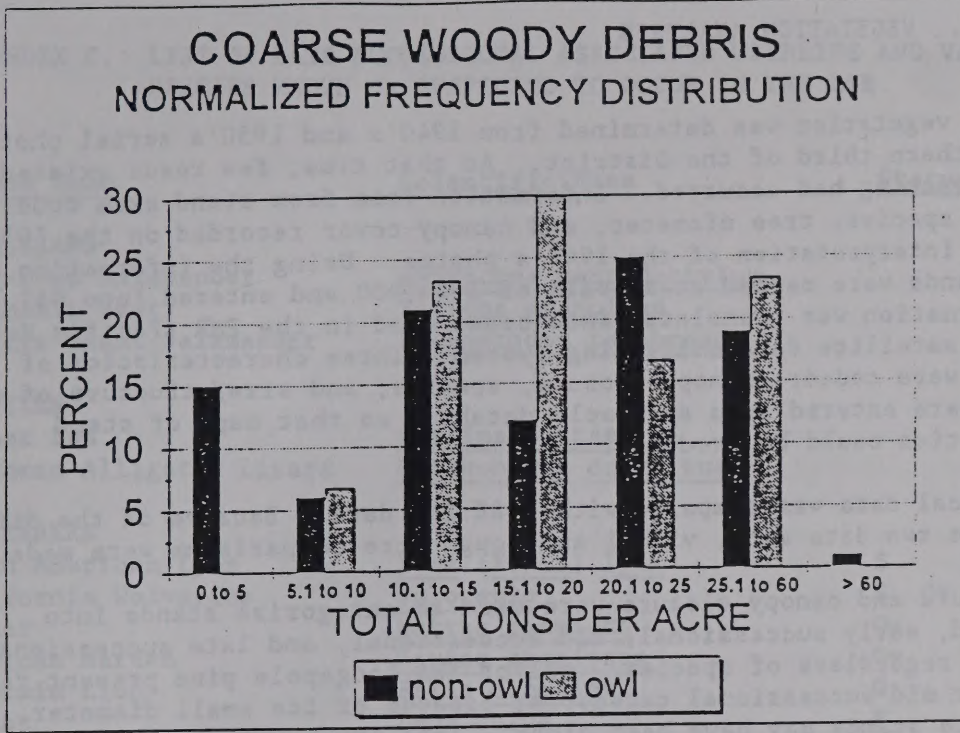

Figure A-5. Coarse Woody Debris.

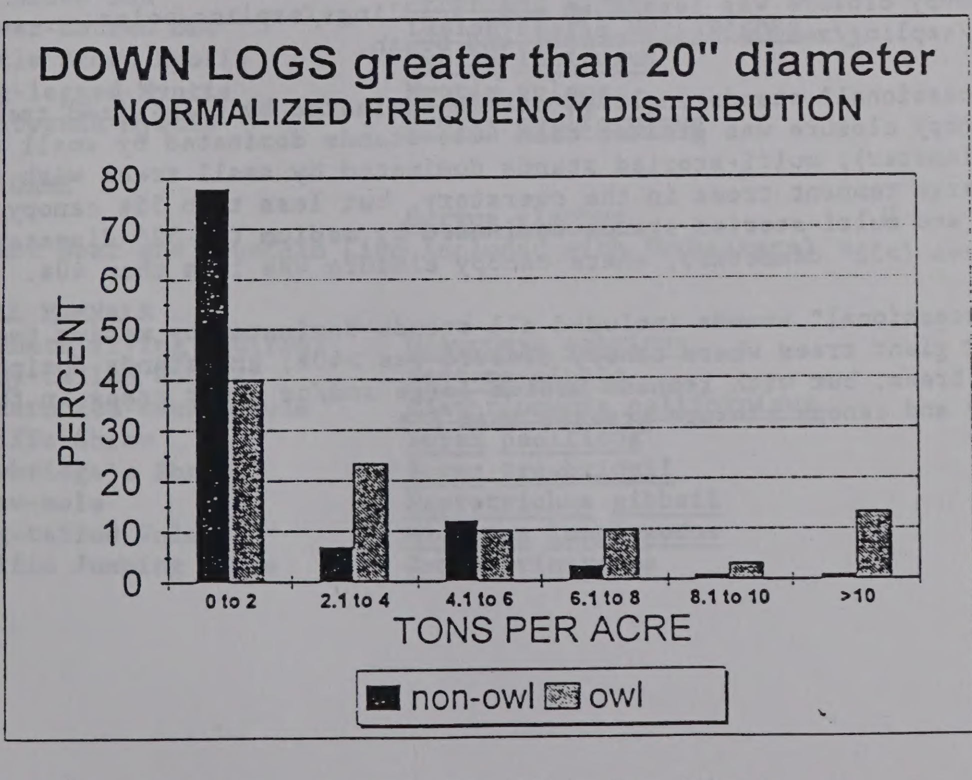

Figure A-6. Down logs greater than 20 inches diameter.

APPENDIX B. VEGETATION ANALYSIS

Historical vegetation was determined from 1940's and 1950's aerial photographs of the northern third of the District. At that time, few roads existed and little harvesting had occurred. Information came from stand exam codes indicating species, tree diameter, and canopy cover recorded on the 1950's photos and interpretation of the 1940's photos. Using the information on the photos, stands were mapped at a scale of 1:24,000 and entered into GIS. The stand information was translated into codes used in the PMR (Pacific Meridian Resources) satellite data collecting system. Three characteristics of vegetation were coded: canopy closure, species, and size/structure of stands. The codes were entered into an Oracle database so that maps of stand characteristics could be produced.

The historical data was compared with 1988 PMR data. Because of the different forms of the two data sets, visual and rough acre comparisons were made.

Size/structure and canopy closure were used to categorize stands into non-forested, early successional, mid successional, and late successional categories, regardless of species. All of the lodgepole pine present fell into the early or mid successional categories because of its small diameter, although some stands may have been older. This error was considered insignificant, because of the small amount of lodgepole pine present. In general, the following definitions were used:

"Non-forested" included rock, lakes, meadows, and wetlands.

"Early successional" included stands with pole-sized trees (5-9" diameter), where canopy closure was less than 40%; seedlings/sapling/poles; seedling/sapling/medium-sized trees; and brush.

"Mid successional" stands included stands dominated by pole-sized trees where canopy closure was greater than 40%; stands dominated by small trees (9-21" diameter); multi-storied stands dominated by small trees with medium and/or large remnant trees in the overstory, but less than 55% canopy closure; and multi-storied stands dominated by medium (21-32" diameter) or large trees (>32" diameter), where canopy closure was less than 40%.

"Late successional" stands included all stands dominated by medium trees, large, or giant trees where canopy closure was >40%; and stands dominated by small trees, but with remnant medium large and/or giant trees in the overstory and canopy closure greater than 55%.

APPENDIX C. LIST OF LATE SUCCESSIONAL ASSOCIATED WILDLIFE AND VASCULAR PLANT SPECIES KNOWN OR SUSPECTED TO OCCUR IN THE LSR.

Common Name	Scientific Name	Status
AMPHIBIANS		
Long-toed Salamander	Ambystoma macrodactylum	
Roughskin Newt	Taricha granulosa	
Pacific Giant Salamander	Dicamptodon tenebrosus	
REPTILES		
Rubber Boa	Charina bottae	
Northern Alligator Lizard	Gerrhonotus coeruleus	
FURBEARERS		
North American Lynx	Lynx (Felis) lynx	S
California Wolverine	Gulo gulo	S, Ot
Fisher	Martes pennanti	Oc
American Marten	Martes americana	Ov
Mountain Lion	Felis concolor	G
Bobcat	Lynx rufus	F
Black Bear	Ursus americanus	G
Ermine	Mustela erminea	F
Long-tailed Weasel	Mustela frenata	F
BATS		
Hoary Bat	Lasiurus cinereus	
Big Brown Bat	Eptesicus fuscus	
Silver-haired Bat	Lasionycteris noctivagans	
Little Brown Myotis	Myotis lucifugus	
Long-legged Myotis	Myotis volans	
California Myotis	Myotis californicus	
BIG GAME		
Elk	Cervus elaphus	G
(Black Bear and Mountain Lion included with Furbearers)		
SMALL MAMMALS		
Northern Flying Squirrel	Glaucomys sabrinus	
Bushy-tailed Woodrat	Neotoma cinera	
Western Red-backed Vole	Clethrionomys californicus	
Pacific Shrew	Sorex pacificus	
Trowbridge's Shrew	Sorex trowbridgii	
Shrew-mole	Neurotrichus gibbsii	
Long-tailed Vole	Microtus longicaudus	
Pacific Jumping Mouse	Zapus trinotatus	

Common Name	Scientific Name	Status
BIRDS OF PREY		
Bald Eagle	Haliaeetus leucocephalus	Ft
Spotted Owl	Strix occidentalis	Ft
Northern Goshawk	Accipiter gentilis	Oc
Great Gray Owl	Strix nebulosa	Ov
Flammulated Owl	Otus flammeolus	Oc, N
Northern Pygmy Owl	Glaucidium gnoma	Ou
Northern Saw-whet Owl	Aegolius acadicus	
WOODPECKERS		
Pileated Woodpecker	Dryocopus pileatus	Oc
White-headed Woodpecker	Picoides albolarvatus	Oc
Red-naped Sapsucker	Sphyrapicus nuchalis	N
Red-breasted Sapsucker	Sphyrapicus ruber	
Williamson's Sapsucker	Sphyrapicus thyroideus	Ou, N
Yellow-bellied Sapsucker	Sphyrapicus various	
NEOTROPICAL MIGRANTS		
Vaux's Swift	Aeronautes saxatalis	N
Calliope Hummingbird	Stelluia calliope	N
Rufous Hummingbird	Selasphorus rufus	N
Olive-sided Flycatcher	Contopus borealis	N
Hammond's Flycatcher	Empidonax hammondii	N
Western Flycatcher (includes Cordilleran and Pacific-slope Flycatcher)	Empidonax difficilis	N
Tree Swallow	Tachycineta bicolor	N
Ruby-crowned Kinglet	Regulus calendula	N
Swainson's Thrush	Catharus ustulatus	N
Hermit Thrush	Catharus guttatus	N
American Pipit	Anthus spinoletta	N
Cedar Waxwing	Bombycilla cedrorum	N
Solitary Vireo	Vireo solitarius	N
Warbling Vireo	Vireo gilvus	N
Red-eyed Vireo	Vireo olivaceus	N
Orange-crowned Warbler	Vermivora celata	N
Yellow-rumped Warbler	Dendroica coronata	N
Black-throated Gray Warbler	Dendroica nigrescens	N
Townsend's Warbler	Dendroica townsendii	N
Hermit Warbler	Dendroica occidentalis	N
MacGillivray's Warbler	Oporornis tolmiei	N
Wilson's Warbler	Wilsonia pusilla	N
Western Tanager	Piranga ludoviciana	N
White-crowned Sparrow	Zonotrichia leucophrys	N
Cassin's Finch	Carpodacus cassinii	N

Common Name	Scientific Name	Status
GAME BIRDS		
Blue Grouse	Dendragapus obscurus	G
Ruffed Grouse	Bonasa umbellus	G
Wood Duck	Aix sponsa	M,G
Common Goldeneye	Bucephala clangula	G
Barrow's Goldeneye	Bucephala islandica	Op,G
Bufflehead	Bucephala albeola	Op,G
Hooded Merganser	Lophodytes cucullatus	G
Commmon Merganser	Mergus merganser	G
OTHER FOREST NESTERS OR FEEDERS		
Black-capped Chickadee	Parus atricapillus	
Mountain Chickadee	Parus gambeli	
Chestnut-backed Chickadee	Parus rufescens	
Red-breasted Nuthatch	Sitta canadensis	
White-breasted Nuthatch	Sitta carolinersis	
Brown Creeper	Certhia americana	
Bewick's Wren	Thryomanes bewickii	
Winter Wren	Troglodytes troglodytes	
Golden-crowned Kinglet	Regulus satrapa	
Varied Thrush	Ixoreus naevius	
Rufous-sided Towhee	Pipilo erythrophthalmus	
Golden-crowned Sparrow	Zonotrichia atricapilla	
LILIACEAE		
Queencup bead lily	Clintonia uniflora	
Branched Solomon's seal	Smilacina racemosa	
Starry Solomon's seal	Smilacina stellata	
Clasping twisted stalk	Streptopus amplexifolius	
Rosy twisted stalk	Streptopus roseus	
Trillium	Trillium ovatum	
ORCHIDACEAE		
Calypso orchid	Calypso bulbosa	
Coralroot	Corallorhiza mertensiana	
Rattlesnake plantain	Goodyera oblongifolia	
Habenaria	Habenaria saccata	
Heartleaf twayblade	Listera cordata	
ASTERACEAE		
Trail plant	Adenocaulon bicolor	
BERBERIDACEAE		
Inside-out flower	Vancouveria hexandra	
CAPRIFOLIACEAE		
Twin flower	Linnaea borealis	

ERICACEAE		
Little prince's pine	Chimaphila menziesii	
Prince's pine	Chimalphila umbellata	
Western wintergreen	Gaultheria humifusa	
Menziesia	Menziesia ferruginea	
Pinedrops	Pterospora andromeda	
Leafless pyrola	Pyrola aphylla	
Pyrola	Pyrola asarifolia	
White vein pyrola	Pyrola picta	
Sidebells pyrola	Pyrola secunda	
Big huckleberry	Vaccinium membranaceum	
Red blueberry	Vaccinium parvifolium	
POLEMONIACEAE		
Mt. Mazama collomia	Collomia mazama	S
RANUNCULACEAE		
Anemone	Anemone oregana	
ROSEACEAE		
Trailing blackberry	Rubus lasiococcus	
RUBIACEAE		
Bedstraw	Galium oreganum	
SAXIFRAGACEAE		
Foamflower	Tiarella trifoliata	
VIOLACEAE		
Stream violet	Viola glabella	

Status Codes:

Fe - Federal endangered, Ft - Federal threatened, Fp - Federal proposed,
S - R6 sensitive, Oe - Oregon endangered, Oc - Oregon critical, Ov - Oregon vulnerable,
Op - peripheral or naturally rare, Ou - Oregon undetermined status, G - game animal,
F - furbearer, N - neotropical migrant, M - migrant

Register.
WA - Recommended by the Washington Department of Wildlife.
OR - Recommended by the Oregon Department of Wildlife.
NF - Recommended by one or more National Forests in response to 2670 Memo of May 7, 1990.
R-1 - Included on the Northern Region Sensitive Species List.
R-5 - Included on the Pacific Southwest Sensitive Species List.
NH1 - Oregon Natural Heritage List 1.
NH2 - Oregon Natural Heritage List 2.

APPENDIX D. SALVAGE GUIDELINES AND WOODY DEBRIS MANAGEMENT

Salvage should be restricted to ensure that appropriate supplies of snags, coarse woody debris (3"+ diameter), and fine fuels (<3" diameter) are maintained. We conducted an investigation into appropriate snag and woody debris levels for plant associations within the OECP LSR's. Our analysis focused on snags and woody debris sufficient to ensure that current productivity is maintained. The analysis and results are described below.

Woody Debris Dynamics

The dynamics of woody debris depend on three different reservoirs of biomass and three different flow rates. The reservoirs consist of the current woody debris on the ground, aerial debris (snags), and green trees, which will die and enter the pool of decomposing biomass. The flow rates include decomposition of woody material in contact with the ground, snag longevity, and live tree mortality.

Recent research (Harmon, 1996) shows that the decomposition rate of white and Shasta red fir is approximately 4 percent per year on the Klamath District. Consequently, the half-life of true fir residues is approximately 17 years. Based on Bussey (1994), we estimated that standing snags have a half-life of 10 years, and all snags from a single mortality event will fall in 20 years. Green tree mortality varies with density and age of stand, but can be modeled, as described below.

Establishing Thresholds

In establishing appropriate thresholds, we focused on desired levels of coarse woody debris (CWD). In "Recommendations for managing coarse woody debris in forests of the northern Rocky Mountains," Russ Graham (unpublished) at the Forestry Sciences Laboratory in Moscow, Idaho, linked minimum CWD levels to habitat types in Idaho and Montana. His recommendations were developed by using ectomycorrhizae as bioindicators of healthy, productive forest soils. Results were obtained for twelve habitat types.

Recognizing a similarity in climate and soils between the east slope of the Cascades and the west slope of the Northern Rockies, we attempted to find analogs of the Graham habitat types in the plant associations of the LSR. Comparisons of species composition and timber productivity, as described in Hopkins (1979), were useful in picking analogs. The results are shown below. All of the lodgepole pine, mountain hemlock, and high elevation Shasta red fir associations appear most similar to the ABLA/VASC habitat type. The low elevation white fir CW-C2-15 association is similar to the ABGR/SPBE habitat type. The low elevation Shasta red fir-white fir CR-S3-11 association is similar to ABLA/XETE. No analog for CW-H1-12, the high elevation white fir association, was found in Graham's sampled habitat types; a CWD value intermediate between CW-C2-15 and CR-S3-11 was estimated. The results of these comparisons give only rough estimates of needed CWD levels; refining these figures would require duplication of Graham's work in the eastern Cascades.

Klamath Plant Association	Rocky Mtn. Habitat Type	CWD (3"+) Level in tons/acre
CW-C2-15	ABGR/SPBE	6.7 - 10.9
CW-H1-12	None	8.7 - 14.0
CR-S3-11	ABLA/XETE	10.7 - 17.7
CR-G1-11		
CR-S1-12	ABLA/VASC	7.0 - 11.4
CL and CM		

Most woody debris on the Klamath District falls in the 3-16" size class range. Typical logs are 12-14" white fir. Material of this size often contains a high proportion of fines, forms high concentrations in some stands, and often jackstraws and creates ladder fuels. An upper limit needs to be set to prevent development of high fire hazard. The recommended tonnages shown above estimate amounts of 3-16" material sufficient for nutrient cycling without significantly increasing fire hazard.

Although most of the material in the OECP LSR's is 3-16" in size, large logs are an important habitat component for many species, and also need to be addressed. Woody debris greater than 16" in diameter does not contribute to fire hazard. Logs of this size contain a low proportion of fines, are generally scattered, and fall through the canopy without creating ladder fuels. There is no ecological reason to limit accumulation of large sized material in any of the plant associations, except in cases where downed material inhibits regeneration, following a stand-replacing event.

Modeling

The Forest Vegetation Simulator can be useful in modeling stand mortality and in assigning tonnages to the result. We used the simulator to predict trends in CWD over time under two different scenarios. The following are examples using the CW-C2-15 plant association.

Regeneration of a clearcut with all woody debris removed:

Decade	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Tons/A	0	0	.3	.7	5.1	9.6	13.3	25.0	33.0	34.2	35.1	33.3	31.6	28.5

Regeneration of a clearcut with thinnings performed in decades 7, 9, and 12:

Decade	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Tons/A	0	0	.3	.7	5.1	9.4	11.8	11.8	5.6	2.1	6.2	4.2	1.6	1.5

Both examples show that removal of all woody debris during site prep can reduce CWD below desired levels for 50 years. Consequently, it is essential at the time of regeneration harvest to leave ample amounts of CWD to prevent this 50-year gap. Using shelterwood harvest techniques would also be useful in mitigating this effect. Retaining species other than true fir, which have slower decomposition rates, can serve as a mitigation as well.

In the first example, without thinning, woody debris reservoirs seem to stabilize with time to amounts which are 4 to 5 times greater than the recommended level.

In the second example, the thinning regime modeled is one which is typically used to meet forest health objectives and reduce risk of beetle kill. This sequence of thinnings appears to reduce mortality rates so much that recruitment of CWD is insufficient to maintain desirable levels. Woody debris generated by thinning appears to be essential in keeping sufficient CWD on the site. This indicates a need to avoid overtreating slash during thinning.

Modeling also indicates that non-traditional thinning regimes need to be developed that allow for more mortality than is traditionally desired. Based on decomposition data, time between thinnings should not exceed 20 years, because thinning serves to replenish the woody debris pool. In addition, target stand densities should be substantially raised in order to allow some level of natural mortality to occur.

Recruitment

Snags are the primary source feeding into the woody debris pool. Using the longevity and decomposition rates previously discussed, aerial tonnage in snags equivalent to about 65% of the desired CWD tonnage should be left on site. For example, in the CW-C2-15 plant association, a minimum of 6.7 tons are necessary on the ground and an additional 4.4 tons should be reserved as snags. Assuming the stand is a typical even-aged white fir stand with a 12" average diameter, we estimated that approximately 10 snags per acre should be retained. We further estimated that in a similar stand of Shasta red fir (CR-S3-11), 15 snags per acre should be retained.

As with large coarse woody debris, snags >16" in diameter do not contribute to fire hazard and should be maintained in all plant associations to provide cavity nesting habitat and future large downed logs.

Where woody debris and snag levels are deficient and recruitment rates are low (primarily in reforestation units), treatments may be needed. Importing woody debris, dropping trees around the edges of units, and scattering cull decks are possible treatments for increasing CWD. Snag creation through girdling or top blasting may also be appropriate.

APPENDIX E. MONITORING RESULTS

Implementation of projects planned using the recommendations in this assessment have not yet been completed. Monitoring data are, therefore, not yet available. However, prior to the signing of the ROD, sales were sold in lands destined to become LSR under Section 318. The advisory boards convened at that time recommended that these sales be carried forward because the prescriptions included modifications consistent with spotted owl biology. Formal monitoring of these sales has been completed and the results are summarized below. Levels of late successional characteristics found to be desirable for spotted owl nesting and roosting on the Klamath District are shown in parentheses.

UNIT	CANOPY LAYERS (>1)	CANOPY CLOSURE (>55%)	DF/PP/SP> 25" (>1 TPA)	SNAGS> 22" (>1 TPA)
Stoney Eagle 1	3	66	6.7	6.8
Stoney Eagle 2	3	38	5.3	6.9
Aros 2	3	66	2.1	4.3
Aros 4	1	29	0.7	0.4
Scout 11	1	44	1.8	0.6
Scout 12	3	46	4.4	1.2
Scout 17	1	84	0.4	0.9
Onion 1	3	99	10.2	1.6
Onion 2	3	90	9.1	4.2
Onion 3	3	86	11.8	8.3
Onion 4	3	63	2.9	5.8
Onion 5	3	97	7.8	6.9
Onion 6	3	79	8.3	8.8
Onion 7	3	61	4.4	3.6
Onion 25	3	46	0.3	4.3
Onion 26	3	53	0.0	2.5
Onion 27	3	57	0.7	7.4
Canal Thin 3	3	76	0.0	1.7
Canal Thin 4	1	84	0.4	0.9

In most cases, the minimum values required for NRF habitat are present after harvest and postsale activities have been completed. In the three units where less than the desirable amount of large Douglas-fir, ponderosa pine, and sugar pine were recorded, desirable levels were not present before the harvest. The units which failed to meet a minimum of 55% canopy closure were all thinnings from below. Prescriptions have since been adjusted to thin stands more lightly to ensure appropriate levels of closure are retained.

[illegible] to become [illegible] that time recommended that these sales be carried forward because the prescriptions included modifications consistent with spotted owl biology. Formal monitoring of these sales has been completed and the results are summarized below. Levels of late successional characteristics found to be desirable for spotted owl nesting and foraging on the Klamath District are shown in parentheses.

UNIT	CANOPY LAYERS (≥2)	CANOPY CLOSURE (≥55%)	DF/PP/SP> 25" (>1 TPA)	SNAGS> 22" (>1 TPA)
Stoney Eagle 1	3	66	6.7	5.5
Stoney Eagle 2	3	58	5.3	6.9
Arva 7	3	45	2.1	4.3
Arva 8	2	25	0.7	0.4
Scout 10	2	49	1.8	0.6
Scout 12	3	60	4.0	1.2
Scout 17	3	55	3.5	0.9
Onion 1	3	59	10.0	1.8
Onion 2	3	50	[illegible]	4.7
Onion 3	3	85	[illegible]	3.1
Onion 4	3	65	2.8	5.8
Onion 5	3	47	7.0	6.5
Onion 6	3	79	8.3	4.2
Onion 7	3	61	4.9	3.5
Onion 25	3	46	5.9	4.3
Onion 26	3	53	9.0	2.5
Onion 27	3	57	9.7	7.6
Canal Thin 3	3	76	6.8	1.7
Canal Thin 4	2	64	6.4	0.9